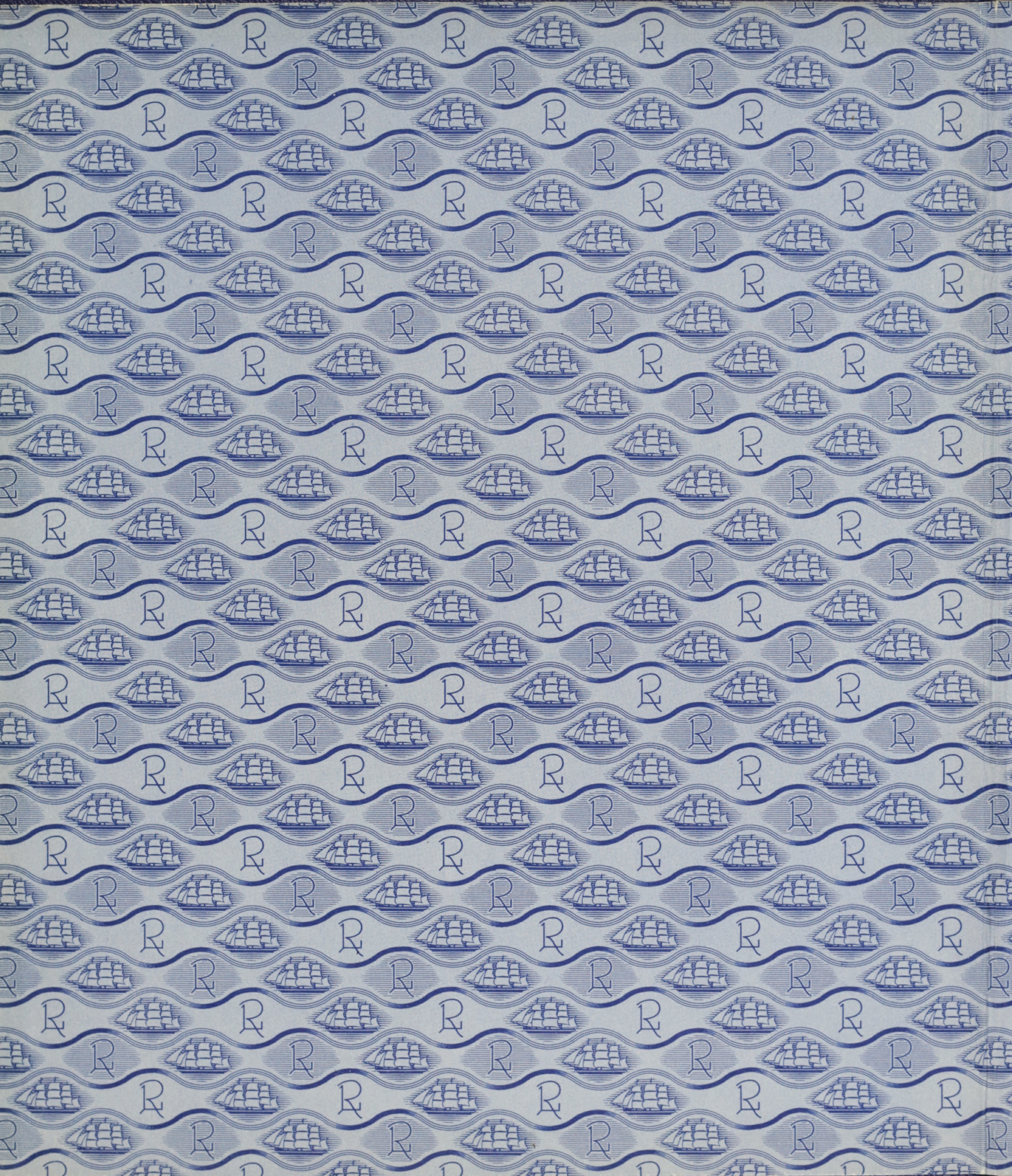


RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1955





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VOLUME I (Register of Ships) contains the names, classes and general information concerning the ships classed by Lloyd's Register and the British Corporation Register; also particulars of all known sea-going merchant ships in the world, and of all iron and steel ships trading on the North American Lakes, of 100 tons gross and upwards.

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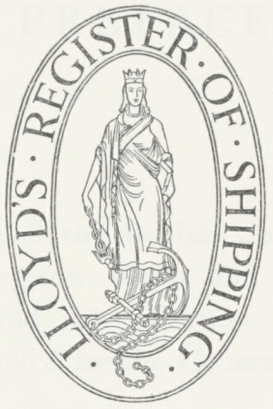
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LLOYD'S REGISTER OF SHIPPING

UNITED WITH THE BRITISH CORPORATION REGISTER

FOUNDED 1760



RECONSTITUTED 1834

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1955

71, FENCHURCH STREET, LONDON, E.C.3

401†

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Chapter B

CLASSIFICATION REGULATIONS

Section 1

CLASSIFICATION

General

101 Steel ships built in accordance with the Society's Rules and Regulations, or with alternative arrangements equivalent thereto (*see* B 501), will be assigned a class in the Register Book and will continue to be classed so long as they are found, upon examination at the prescribed annual and other periodical surveys, to be maintained in such fit and efficient condition as is prescribed by the Society's Rules for the safe carriage of dry and perishable or other approved cargoes.

In cases where the scantlings and arrangements have been approved by the Committee for stipulated cargoes of a special nature, a class notation indicating the nature of such cargo may be entered in the Register Book.

Classification will be conditional upon compliance with the Society's requirements in respect of both hull and machinery (i.e., main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment).

The Rules are framed on the understanding that ships will be properly loaded and handled.

The scantlings and arrangements prescribed in the Construction Rules do not provide for any special distribution or concentration of loading. When it is desired to make provision for exceptional loaded or ballasted conditions, the necessary particulars are to be submitted for consideration; in such cases additional strengthening may be required. The Committee may also require additional strengthening to be fitted in any ship which, in their opinion, may be subjected to severe stresses due to particular features in her design.

The responsibility for ensuring sufficient stability and suitable trim does not rest on the Committee.

The attention of Owners and Builders is directed to national and international statutory safety regulations for passenger and cargo ships governing navigation, life saving appliances and other arrangements which are not covered by the Society's Rules or classification.

Character of Classification and Class Notations

102 Class 100A1. This character will be assigned to all sea-going ships built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings, arrangements and equipment given in the Construction Rules for the draught required.

103 Class 100A1 FOR SPECIAL SERVICE. This class will be assigned to sea-going ships intended for special services and built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings, arrangements and equipment approved by the Committee for such ships. The class notation affixed to the character in the Register Book will indicate the particular service for which the ship is approved, e.g., Dredger; Hopper Barge; For Towing Services.

104 Class 100A1 FOR RESTRICTED SERVICE. This class will be assigned to sea-going ships intended to trade within specified limits and built in accordance with the Society's Rules and Regulations and the scantlings, arrangements and equipment approved by the Committee for the intended service. The class notation affixed to the character in the Register Book will indicate the particular service for which the ship is approved, e.g., For Coasting Service; For Channel Service, and the geographical limits of the service will be defined.

105 Class 100A1 Carrying Petroleum in bulk. This class will be assigned to tankers intended to carry petroleum in bulk and built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings, arrangements and equipment given in the relevant Chapters of the Construction Rules.

Where the scantlings and arrangements have been approved by the Committee for the carriage of oil having a flash point above 150° Fahrenheit, or other liquid cargoes in bulk, the class notation affixed to the character may be suitably modified.

106 Class 100A1 Ore Carrier. This class will be assigned to sea-going ships specially designed for the carriage of ore and built in accordance with, or by standards equivalent to, the Society's Rules and Regulations and the scantlings, arrangements and equipment given in the relevant Chapters of the Construction Rules.

107 Class A1 FOR RESTRICTED SERVICE. This class will be assigned to ships intended to trade only within specially sheltered waters such as harbours, rivers or estuaries, provided the scantlings, arrangements and equipment are approved by the Committee as suitable for such service. A class notation will be affixed to the character indicating the particular service for which the ship has been approved.

Special Cargoes

108 In dry cargo ships, any compartments intended for the carriage of liquid cargoes, such as vegetable or mineral oils having a flash point above 150° F., are to be in accordance with the requirements of the Construction Rules relating thereto; in such cases, an appropriate class notation will be entered in the Register Book.

Ice Strengthening

109 Where the class notation "Strengthened for navigation in ice" is desired, additional strengthening is to be fitted in accordance with the special requirements given in the Construction Rules.

Other Notations

110 Descriptive notations may be made in the Register Book when deemed necessary by the Committee to indicate any special features in the design or construction of a ship or its machinery.

Section 2

EQUIPMENT

201 The figure 1 in the character of classification assigned to a ship relates to her equipment of anchors, chain cables and hawsers. For sea-going ships intended to be classed for unrestricted service (B 102, B 105) the equipment is to be supplied in accordance with, or of a standard equivalent to, the detailed requirements set forth in the Construction Rules.

For sea-going ships intended to be classed for a special or restricted service (B 103, B 104) or for ships intended to be classed for trade within specially sheltered waters (B 107), the equipment is to be of a standard acceptable to the Committee for the service intended.

The Committee will give special consideration to ships intended to be classed for service within specially sheltered waters (B 107), for which, by reason of their particular purpose or service, normal equipment may be unnecessary. In such cases the figure 1 may be omitted from the character of classification or such class assigned as the Committee may deem necessary.

202 In the case of any ship already classed 100A1 or A1 for which a temporary deficiency in quantity or quality of the approved equipment cannot be restored within a reasonable time, the Committee may at their discretion amend the class by deleting the figure 1 and inserting a line in the character of classification, thus: 100A–, until such time as the equipment has been replaced to the Society's requirements. In any

such case, however, and in all cases of ships originally classed 100A– or A–, the Committee will require to be kept advised of the equipment actually provided, and if this is found to be so seriously deficient in quantity or quality as to impair the safety or efficiency of the ship, the class will be liable to be expunged from the Register Book.

203 The requirements of 202 will similarly be applied to any ship holding a British Corporation class except that the notation (EI) indicating equipment incomplete will be used and affixed to the character of classification in the Register Book in those cases in which there is a temporary deficiency in equipment.

Section 3

MACHINERY

301 The machinery, as defined in B 101, is to be constructed and installed on board ship in accordance with the Society's Rules and Regulations. On satisfactory completion of trials, an appropriate class notation will be assigned in the Register Book, thus, LMC (Lloyd's Machinery Certificate).

Section 4

MATERIALS

401 The materials used in the construction of hulls and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested under the supervision of the Society's Surveyors in accordance with the requirements of Chapter P. The steel is to be manufactured by an approved process at works recognised by the Committee.

Section 5

EQUIVALENT ARRANGEMENTS

501 Alternative arrangements to those prescribed in the Rules will be permitted, provided they are submitted to the Committee and considered by them to be equivalent to the Society's requirements. The Owners' consent shall be obtained to such alternative proposals when the Committee deem this necessary.

Section 6

NEW CONSTRUCTION

Submission of Plans

601 When it is intended to build a ship for classification with the Society, constructional plans and particulars of the hull, equipment and machinery (*see* B 101), as detailed in the respective Chapters of the Construction Rules, are to be submitted through the local Surveyors for the approval of the Committee before the work is commenced.

Any subsequent modifications or additions to the scantlings, arrangements or equipment shown on the approved plans are also to be submitted for approval.

Novel Forms of Construction

602 Where the proposed construction of any part of the hull or machinery is novel in design, or involves the use of unusual material, or where experience has, in the opinion of the Committee, not sufficiently justified the principle or mode of application involved, special tests or examinations before and during service may be required, and a suitable notation inserted in the Register Book when the Committee consider this necessary.

Special Survey during Construction

603 New ships intended for classification are to be built under the Society's Special Survey and when classed will be entitled to the distinguishing mark ✠ inserted before the character in the Register Book thus: ✠100A1.

New machinery for ships classed or intended for classification is to be constructed under the Society's Special Survey, and on completion will be entitled to the distinguishing mark ✠ inserted before the machinery class notation in the Register Book, thus: ✠LMC.

During the construction, from the commencement of the work until the completion of the ship and final test of the machinery under working conditions, the Surveyors are to examine the materials and workmanship and are to indicate, and require the rectification of, any items not in accordance with the Rules or the approved plans, or any material, workmanship or arrangement found to be defective or unsatisfactory.

Date of Build

604 The date of completion of the Special Survey during Construction of ships built under the Society's inspection will normally be taken as the date of build to be entered in the Register Book. If, however, the period between launching and completion or commissioning is, for any reason, unduly prolonged, the dates of launching and completion or commissioning may be separately indicated in the Register Book.

In any case in which a ship upon completion is not immediately put into commission, but is laid up for a period, the Committee, upon application by the Owner, prior to the ship proceeding to sea, may direct an examination of the ship to be made in dry dock by the Society's Surveyors. If, as the result of such survey, the hull and machinery be reported in all respects free from deterioration, the subsequent Special Survey will date from the time of such examination.

Section 7

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

701 The requirements of the Committee for the classification of ships which have not been built under the Society's survey are set forth in C 11.

Section 8

PERIODICAL SURVEYS

Annual and Docking Surveys

801 All steel ships classed with the Society are subject to survey at intervals of approximately one year, in accordance with the requirements set forth in C 1.

Owners or their representatives should notify the Society or its Surveyors whenever a ship can be examined in dry dock or on a slipway. Ships should be examined in dry dock approximately once a year and the interval between such examinations is not to exceed two years.

The date of the last examination in dry dock or on a slipway will be recorded in the Supplement to the Register Book.

Special Surveys

802 All steel ships classed with the Society are also to be subjected to Special Surveys in accordance with the requirements set forth in C 2 to C 7. These surveys become due at 4-yearly intervals, the first 4 years from the date of build or date of Special Survey for Classification, and thereafter 4 years from the date of the previous Special Survey.

Period allowed for completion of Special Surveys

803 When it is inconvenient for Owners to fulfil all the requirements of a Special Survey at its due date, the Committee will be prepared to consider its postponement, either wholly or in part, provided that the Society's Surveyors are afforded an opportunity, about the due date, of assessing the general condition of hull and machinery. For this purpose the Committee will normally call for a general examination of the ship, including drydocking, of sufficient extent to be assured that her condition is satisfactory for the period of grace desired, which is not to exceed 12 months from the due date.

Special Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee, who will be prepared to consider suitable arrangements for carrying out Special Surveys over an extended period in the case of ships engaged on a regular schedule.

Record of Special Surveys

804 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the date and place of such survey, e.g., Lon 11/54. For Special Surveys at which the prescribed requirements as to drilling of the shell and strength deck plating have been complied with, the record will be entered thus: Lon (Dr) 11/54. Where a Special Survey is not completely carried out at one time, the date recorded in the Supplement will be the date at which the principal part of the requirements is complied with. Records of Special Survey will not be assigned until the Society's requirements for machinery surveys detailed in 805 or 806 are satisfactorily completed.

Surveys of Machinery

805 Machinery, as defined in B 101, is to be submitted to the surveys set forth in C 4 to C 10.

Complete Surveys are to be carried out as part of the Special Survey. Parts of the machinery which have been examined within the preceding 12 months need not be re-examined except in special circumstances. On satisfactory completion of the survey an appropriate record will be made in the Supplement to the Register Book. Where a Complete Survey of the machinery is not carried out at one time the date recorded in the Supplement will be that on which the first portion of the survey is carried out.

If, upon examination, it is found desirable that any part of the machinery should be again examined before the due date of the next survey, a certificate for a limited period will be granted in accordance with the nature of the case.

Continuous Surveys of Machinery

806 In cases where, at the request of Owners, it has been agreed by the Committee that the Complete Survey of the machinery may be carried out on the continuous survey basis, the various items of machinery should, so far as practicable, be opened for survey in rotation to ensure that the interval between consecutive examinations of each item will not exceed the period normally allowed by the Regulations between Special Surveys, and the survey cycle should be completed coincidently with the Special Survey on the hull; this procedure will be regarded as providing compliance with the requirements of 802.

In such cases a record indicating the date of completion of the cycle will be made in the Supplement to the Register Book.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor and the defects made good to his satisfaction.

Modified Surveys of Oil Engines

807 Modified Surveys of oil engine machinery, as detailed in C 6, are to be carried out as they become due, namely, 2 years from the last recorded Complete Survey of machinery. On satisfactory completion, an appropriate record will be made in the Supplement to the Register Book.

If the examination at a Modified Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor and the defects made good to his satisfaction.

Modified Surveys will not be required in cases where the machinery is examined on the Continuous Survey basis.

Boiler, Steam Pipes and Screw Shaft Surveys

808 Boiler Surveys, examination of Steam Pipes and Screw Shaft Surveys should be carried out as set forth in C 8, C 9 and C 10. On satisfactory completion, appropriate records will be made in the Supplement to the Register Book.

Progressive Surveys

809 In the case of passenger ships engaged on a regular service, when the exigencies of the service render it difficult to carry out the Special Surveys at the times prescribed in this Section, the Committee will be prepared, at the request of Owners, to consider suitable arrangements for a progressive survey of the hull. In such cases all compartments of the hull are to be progressively surveyed and tested, so that the survey cycle is completed during the period normally allowed by the Regulations between Special Surveys, and the time which elapses between consecutive examinations and testing of each compartment is not to exceed that period. The machinery surveys in these cases are to be carried out as required for continuous surveys.

Records in respect of such progressive surveys will be made in the Supplement to the Register Book, and the classification certificates endorsed as considered necessary by the Committee.

Section 9

REFRIGERATION

901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Refrigeration Section of the Appendix to the Register Book.

902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port and other Surveys set forth in N 8.

Section 10

REPAIRS AND ALTERATIONS

Repairs

1001 All repairs to hull, equipment and machinery which may be required in order that a ship may retain her class are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors. When repairs are effected at a port where there is no Surveyor to this Society, the ship is to be surveyed by one of the Society's Surveyors at the earliest opportunity.

1002 When at any survey the Surveyors consider repairs to be necessary, either as a result of damage, or of wear and tear, they will communicate their recommendations at once to the Owners, or their representative, and if compliance therewith cannot be arranged, immediate notification will be given to the Committee.

Alterations

1003 Plans and particulars of any proposed alterations to the approved scantlings and arrangements of hull, equipment, or machinery are to be submitted for approval and such alterations are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors.

Section 11

APPEAL FROM SURVEYORS' RECOMMENDATIONS

1101 If the recommendations of the Society's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a special examination to be held.

Section 12

NOTICE OF SURVEYS

1201 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Special Surveys become due, but the non-receipt of such notice, or of notice regarding other surveys, does not absolve Owners from this responsibility.

Section 13

CERTIFICATES

1301 When the required reports on completion of the Special Surveys of new ships, or of existing ships submitted for classification, have been received from the Surveyors and approved by the Committee, certificates of first entry of classification, signed by the Chairman, Deputy-Chairman and Treasurer, or Deputy-Chairman and Chairman of the Sub-Committees of Classification, and countersigned by the Secretary, will be issued to Builders or Owners.

1302 Certificates of class maintenance in respect of completed periodical surveys of hull and machinery will also be issued to Owners on application.

1303 The Society's Surveyors are permitted to issue provisional certificates to enable a ship, classed with the Society, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such certificates will embody the Surveyor's recommendations for continuance of class, but in all cases are subject to confirmation by the Committee.

Section 14

WITHDRAWAL OF CLASS

Owners' Request

1401 When the class of a ship, for which the Regulations as regards surveys on hull, equipment and machinery have been complied with, is withdrawn by the Committee in consequence of a request from the Owners, the notation "CLASS WITHDRAWN at Owners' request" (with date) will be made in the Supplement and, in due course, in the Register Book.

Non-Compliance with the Regulations

1402 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be expunged and the notation "CLASS EXPUNGED—Non-compliance with Regulations" (with date) will be made in the Supplement and, in due course, in the Register Book.

Reported Defects

1403 When it is found from reported defects in the hull or equipment or machinery that a ship is not entitled to retain her class in the Register Book, and the Owners fail to repair such defects in accordance with the Society's requirements, the class will be expunged and the notation "CLASS EXPUNGED—Reported defects" (with date) will be made in the Supplement and, in due course, in the Register Book.

Infringement of Freeboard Conditions

1404 Where any ship proceeds to sea with a less freeboard than that approved by the Committee or where the freeboard marks are placed higher on the ship's sides than the position assigned or approved by the Committee, the ship's class will be liable to be expunged.

Section 15

RECLASSIFICATION OF SHIPS

1501 When reclassification is desired for a ship for which a character of classification in the Register Book previously assigned has been withdrawn, or deleted, application is to be made to the Committee in writing.

The Committee will in such cases direct a Special Survey for Reclassification, appropriate to the age of the ship and circumstances of the case, to be carried out by the Society's Surveyors.

If at such survey the ship be found or placed in a good and efficient condition in accordance with the requirements of the Rules and Regulations and to the satisfaction of the Surveyors, the Committee will be prepared to reinstate her original character of classification or assign such other character as may be deemed necessary.

The date of reclassification will be recorded in the Supplement to the Register Book and this date will govern the subsequent Special Survey required by the Regulations for maintenance of class.

March, 1954

Reduction Gears, complete with all wheels, pinions, shafts, bearings and gear teeth.

Auxiliary Engines, auxiliary air compressors and their intercoolers, and all pumps and components used for essential services.

Steering Machinery.

Windlass.

Evaporators and their safety valves, which should be seen in operation under steam.

Securing Arrangements

The holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings.

Air Receivers

All air receivers for essential services with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

Pumping Arrangements

The valves, cocks and strainers of the bilge system including bilge injection, are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. The oil fuel, feed and lubricating oil systems and the ballast connections and blanking arrangements to deep tanks which may carry liquid or dry cargoes, together with all pressure filters, heaters and coolers used for essential services, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing items are to be examined.

Fuel Tanks and Fittings

Fuel tanks which do not form part of the ship's structure are to be examined and if considered necessary by the Surveyor they are to be tested to the pressure specified for new tanks. All mountings, fittings and deck controls are to be examined as far as practicable.

Fire Extinguishing Systems in Machinery Spaces and Pump Rooms

The apparatus is to be examined to ensure that it is maintained in an efficient condition.

In addition to the above, detailed requirements for steam and internal combustion engines, electrical installations and boilers are given in C 5, C 6, C 7 and C 8 respectively.

Section 5

STEAM ENGINES—DETAILED REQUIREMENTS

Complete Surveys

501 In addition to the requirements of C 4 the working parts of the main engines and attached pumps and of auxiliary machinery used for essential services including bulkhead stop valves, manœuvring valves, cylinders, pistons, valves and valve gear, piston rods, connecting rods, crossheads and guides, the crank shafts of reciprocating engines and the blading, rotors and casings of turbine machinery are to be opened up and examined.

Condensers, steam reheaters, desuperheaters which are not incorporated in the boilers and any other appliances used for essential services are to be examined to the satisfaction of the Surveyor, and if considered necessary they are to be tested.

502 Exhaust steam turbines supplying power for main propulsion purposes in conjunction with reciprocating engines are, together with their gearing and appliances, steam compressors or electrical machinery, to be examined as far as practicable. Where cone connections to internal gear shafts are fitted, the coned ends are to be examined as far as practicable.

503 In steam ships having essential auxiliary machinery driven by internal combustion engines, the prime movers of these auxiliaries are to be examined as detailed in C 601.

Section 6

INTERNAL COMBUSTION ENGINES—DETAILED REQUIREMENTS

Complete Surveys

601 In addition to the requirements of C 4 the Complete Survey is to consist of the opening out and examination of the following parts: cylinders, covers, valves and valve gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, compressors, their intercoolers and safety devices, pistons, piston rods, crossheads, guides, connecting rods, crank shafts and all bearings, clutches, reverse gears, attached pumps, cooling system, crankcase door fastenings and explosion relief devices. The electric ignition system, if fitted, is to be examined and tested. The manœuvring of engines is to be tested under working conditions.

Where steam is used for essential purposes, the condensing plant, feed pumps, and oil fuel burning plant, are to be examined and the steam pipes examined and tested as detailed in C 9.

Modified Surveys

602 The Modified Survey is to include, for each main engine, the examination of at least two cylinders with their covers, valves and valve gear, pistons, piston rods, crossheads, guides and connecting rods, and two of the crank shaft pins, journals and main bearings. In main engines having less than four cylinders, and in each auxiliary oil engine, one each of the above mentioned parts will be considered sufficient. The electrical ignition system, if fitted, is to be examined and tested.

A general examination as far as practicable is to be made of valve gears, pumps, air compressors, clutches, reverse gears, air receivers, oil fuel storage tanks and their connections, and if they are found satisfactory they need not be opened out.

Section 7

ELECTRICAL EQUIPMENT

701 At each Special Survey the electrical equipment is to be examined and tested in accordance with 702 to 710.

NOTE.—In cases where the Committee have consented to Continuous Surveys, the electrical equipment may also be included in the survey cycle. (*See* B 806.)

702 A test for insulation resistance is to be made on the cables, switchgear, generators, motors, heaters, lighting fittings, etc., and the insulation resistance is to be not less than 100,000 ohms between all insulated circuits and earth. The installation may be sub-divided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

703 The fittings on main and emergency switchboards, section boards and sub-distribution fuse boards are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

704 Generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily.

705 The electric cables are to be examined as far as practicable without undue disturbance of fixtures or casings unless opening up is considered necessary as a result either of observation or of the tests required by 702.

706 The generator prime movers are to be surveyed as required by C 5 and C 6 and the governing of the engines tested. The motors concerned with essential services together with associated control and switch gear are to be examined and if considered necessary are to be operated as far as practicable under working conditions. All generators and steering gear motors are to be examined and are to be operated under working conditions though not necessarily under full load or simultaneously.

707 Where transformers or electrical apparatus associated with supplies to essential services are oil-immersed, the Owners are to arrange for samples of oil to be taken and tested for breakdown voltage, acidity and moisture by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

708 Where electro-magnetic couplings are fitted, the air gaps are to be measured and reported and any excessive eccentricity corrected. The couplings and associated switch gear are to be examined and tested.

709 Navigation light indicators are to be tried under working conditions and correct operation on the failure of supply and failure of navigation lights verified.

Electric Propelling Machinery

710 Where the ship is electrically propelled, the propulsion motors, generators, cables, and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and slip-rings. The operation of protective gear and alarm devices is to be checked as far as practicable. Insulating oil, if used, is to be tested in accordance with 707. Interlocks intended to prevent unsafe operations or unauthorised access are to be checked to verify that they are functioning correctly. Emergency overspeed governors are to be tested.

Section 8

BOILER SURVEYS

801 All water tube boilers and other types which have water tubes as an integral part are to be examined at annual intervals from the date of construction. In boilers employing forced circulation, the pumps used for this purpose are to be opened and examined at each boiler survey.

802 Other boilers, including exhaust gas heated or steam heated generators, economisers, cross-tube boilers, thimble tube boilers, domestic boilers whose working pressure exceeds 50lb. per square inch or whose heating surface exceeds 50 square feet, also press boilers and similar apparatus in floating whale oil factories are to be surveyed when they are 4 years old, also when they are 6 years old and subsequently at annual intervals.

803 At the surveys described in 801 and 802 the boilers, superheaters and economisers are to be examined internally and externally and where considered necessary the pressure parts are to be tested by hydraulic pressure and thickness of plates and tubes and size of stays are to be ascertained to determine a safe working pressure. The principal mountings on boilers, superheaters and economisers are to be opened up and examined and the safety valves adjusted under steam to a pressure not greater than 3 per cent above the approved working pressures of the respective parts. The remaining mountings are to be examined externally and are to be opened up for internal examination if considered necessary by the Surveyor. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition.

804 The oil fuel burning system is to be examined under working conditions and a general examination made of fuel tank valves, pipes, deck control gear and oil discharge pipes between pumps and burners.

805 At each survey of a cylindrical boiler which is fitted with smoke tube superheaters, the saturated steam pipes are to be examined as detailed in C 905.

Section 9

STEAM PIPES

Steel Pipes

901 At intervals of 6 years from the date of build, a selected number of main and superheater steam pipes and auxiliary steam pipes over 3 inches internal diameter, supplying steam for essential purposes at sea, are to be removed for internal examination and hydraulically tested to twice the working pressure.

902 If these selected pipes are in all respects found to be satisfactory, the remainder need not be tested.

903 In cylindrical boilers having smoke tube superheaters where the saturated steam pipes adjoining the saturated steam headers are in part situated in the boiler smoke boxes, all saturated steam pipes adjoining and cross-connecting the saturated steam headers in the smoke boxes are, at the above-mentioned intervals, to be included in the number of pipes selected for examination.

904 Where the saturated steam pipes inside the smoke boxes consist of steel castings of substantial construction the requirements of 903 need only be applied to a sample casting.

905 Where the steel castings in 904 are not fitted the Surveyor should satisfy himself of the condition of the ends of the saturated steam pipes inside the smoke boxes at each boiler survey, and if it is considered necessary a sample pipe should be removed for further examination.

906 As an alternative to the requirements of 901 and provided the saturated steam pipes are dealt with as detailed in 903, 904 and 905, the remainder of the steam pipes may, at the Owners' desire, be hydraulically tested in place to twice the working pressure. Lagging is to be removed as required by the Surveyor to permit effective examination.

Copper Pipes

907 At intervals of 6 years from the date of build all copper steam pipes above 3 inches internal diameter are to be annealed and thereafter hydraulically tested to twice the working pressure.

908 Copper pipes with brazed longitudinal joints are to be annealed and hydraulically tested to twice the working pressure at 4-yearly intervals.

Section 10

SCREW SHAFTS AND TUBE SHAFTS

1001 Screw shafts and tube shafts are to be drawn periodically for examination by the Society's Surveyors.

Where shafts are fitted with continuous liners or approved oil glands they normally become due for survey at intervals of 3 years for single screw ships and 4 years for ships having two or more screws. All other shafts should be drawn at intervals of 2 years.

On the application of Owners, the Committee will be prepared to give consideration to the circumstances of any special case.

Section 11

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

1101 When classification is desired for a ship not built under the supervision of the Society's Surveyors, application should be made to the Committee in writing.

Hull and Equipment

1102 Plans showing the main scantlings and arrangements of the actual ship and any proposed alterations are to be submitted for approval. These should comprise midship section, longitudinal section and decks, and such other plans as may be requested. If plans cannot be obtained or prepared by Owners, facilities are to be given for the Society's Surveyor to take the necessary information from the ship.

Particulars of the process of manufacture and testing of the material of construction should be furnished.

1103 In all cases the full requirements of C 201 to C 229 are to be carried out. In the case of petroleum tankers the requirements of C 301 to C 305 are also to be carried out. Petroleum tankers over 12 years old are in addition to comply with C 306, and other ships over 20 years old with C 230 and C 231. During the survey the Surveyors are to satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be drilled as necessary. Full particulars of the anchors, chain cables and equipment are to be submitted.

Ships of recent construction will receive special consideration.

1104 When the full survey requirements indicated above cannot be completed at one time, the Committee may consider granting an interim record for a limited period. The conditions regarding the completion of the survey will depend on the merits of each particular case, which should be submitted for consideration.

Machinery

1105 To facilitate the survey, plans of the following items, together with the particulars of the materials used in the construction of the boilers, air receivers and important forgings should be furnished:—

General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)

Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

General arrangement of cargo piping in tanks and on deck of oil tankers.

Piping arrangements for cargo oil (F.P. above 150° F.).

Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangement of oil fuel piping in connection with oil burning installations.

Oil fuel and cargo oil overflow systems, where these are fitted.

Arrangement of boiler feed systems.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Plans of machinery space piping are to be diagrammatic.

Boilers, superheaters and economisers.

Air receivers.

Crank, thrust, intermediate and screw shafting.

Clutch and reversing gear.

Reduction gearing.

Electrical circuits.

NOTE.—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

TORSIONAL VIBRATION CHARACTERISTICS

For new ships and ships which have been in service less than 8 years calculations of the torsional vibration characteristics of the propelling machinery are to be submitted for consideration as required for ships constructed under Special Survey. For older ships the circumstances will be specially considered in relation to their service record and type of machinery installed.

Where calculations are not submitted the Committee may require that the machinery certificate be endorsed to this effect.

When desired by the Owners the calculations and investigation of torsional vibration characteristics of machinery may be carried out by the Society upon special request.

1106 The main and auxiliary machinery, also feed pipes, compressed air pipes and boilers are to be examined as required at Special Surveys, and their working pressures are to be determined from their actual scantlings in accordance with the Rules.

The screw shaft is to be drawn and examined.

The steam pipes are to be examined and tested as required by C 9.

The bilge, ballast and oil fuel pumping arrangements are to be examined and amended as necessary to comply with the Rules.

Oil burning installations are to be examined as required at Special Surveys and found, or amended, to comply with the requirements of the Rules ; they are also to be tested under working conditions.

The electrical equipment is to be examined as required at Special Surveys.

The fire extinguishing arrangements are to be in accordance with the requirements of the Rules (*see* Chapter F).

The whole of the machinery is to be tried under working conditions to the Surveyors' satisfaction.

First entry reports are to be prepared by the Surveyors.

Periodical Surveys

1107 Periodical surveys are subsequently to be held as in the case of ships built under survey.

March, 1954

Chapter D

STEEL SHIPS

Section 1

GENERAL

Determination of Scantlings

101 The scantlings in the Tables are related in general to basic dimensions and, where necessary, to a basic moulded draught. Corrections are given in the Tables, or associated notes, for use where the actual dimensions or draught of the ship differ from those in the Tables. The Rules and Tables are framed for ships of normal ratio of breadth to depth and having proportions of length to depth at the strength deck not exceeding thirteen and a half.

If the proportions are abnormal, special structural arrangements will be required.

The minimum scantlings given by the Tables may require to be increased on account of particular features in general design or when Owners desire to make provision for exceptional distributions or concentration of loading (*see* B 101, D 34 and Table 18, note 2(*e*)).

Assignment of Class

102 The class 100A1 will be assigned in accordance with the provisions of Chapter B to all sea-going ships when the requirements of the Rules have been complied with for the draught required.

Material

103 The Rules and Tables are based on the use of mild steel which complies with the requirements of Chapter P. Where special quality steel or other material is used the scantlings will be specially considered.

The scantlings of rolled sections in the various Tables are based on the British Standards as revised in 1924.

Method of Construction

104 The Rules and Tables set forth requirements for riveted construction together with certain modifications where electric arc welding is adopted.

Particulars indicating the principal parts which are electrically welded will be given in the Register Book as deemed desirable by the Committee.

Interpolation

105 For dimensions and draughts between the values given in the Tables the scantlings are to be obtained by interpolation.

Distribution of Material

106 The scantlings given in the Tables for the midship portion of the ship are to be reduced gradually to those given for the ends.

Equivalents

107 Alternative arrangements or fittings which are considered to be equivalent to the requirements of the Rules will be accepted by the Committee but the Owner's sanction may be required.

Submission of Plans

108 For each ship proposed to be built under survey for classification in the Register Book plans of midship and longitudinal sections, on which the designed summer moulded draught is to be given together with the particulars necessary for calculation of freeboard, are to be submitted for approval.

The following plans are also to be submitted:—

Shell plating.
Decks.
Watertight bulkheads.
Pillars and girders.
Deep tanks.
Oil fuel bunkers.
Arrangements to resist panting.
Strengthening of bottom forward.
Rudder and sternframe.
Propeller brackets.
Bossed framing.
Motor and thrust seating.
Cruiser stern.
Long deckhouses.
Hatchways.
Main steering gear of rod and chain type and auxiliary steering gear.
Strengthening for navigation in ice.
Pumping arrangements.
Scheme of riveting.
Scheme of welding.

Section 2

DEFINITIONS

201 Length L is the distance in feet on the summer load waterline from the fore side of stem to the after side of rudder post, or to the centre of rudder stock if there is no rudder post, but L is not to be less than 96 per cent of the extreme length on the summer load waterline.

Amidships is to be taken as the middle of the length L.

202 Breadth B is the greatest moulded breadth in feet.

203 Depth D is measured in feet at the middle of the length L from top of keel to top of deck beam at side.

D for Shell and Topside Plating is measured to the strength deck as defined in 207.

D for Framing is measured to the uppermost continuous deck.

204 Draught d is the summer draught in feet measured from top of keel.

205 Depth h for Framing is measured in feet from the top of the double bottom or single bottom floor at side to the top of beam at side of the lowest deck.

206 Effective Superstructure is a midship superstructure extending from side to side of the ship and exceeding ·15L in length.

207 Strength Deck is the uppermost continuous deck except in way of an effective superstructure where the superstructure deck is to be considered the strength deck.

Section 3

KEELS, STEMS AND STERNFRAMES

Materials

301 Steel castings are to comply with the requirements of P 9.

302 Forgings made of ingot steel are to comply with the requirements of P 10.

303 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Plate Keels

304 The scantlings of plate keels are given in Table 14. Plate keels are to be associated with centre keelsons or centre girders as required by D 4 or D 5.

Bar Keels

305 The scantlings of bar keels are given in Table 1.

Riveted scarphs connecting the separate lengths together, or to the stem and sternpost, are to have a length of nine times the thickness of the bar.

Stems

306 Bar stems are to have the scantlings given in Table 1, but above the load waterline the dimensions may be gradually tapered to the stem head where the sectional area may be 75 per cent of the area derived from the Table.

307 If the stem is constructed of shaped plates the thickness of the plates below the load waterline is to be 10 per cent greater than the thickness of the side shell plating given in Table 14, col. 8, without corrections; above the load waterline the thickness may be gradually tapered towards the stem head where it may be equal to the shell plating at ends. Plates which require to be furnaced are to have these thicknesses when finished.

The plates are to be supported by horizontal webs between the decks and below the lowest deck; the unsupported length of the stem plates is not to exceed 5 feet. Where the radius of the plates is large a centre line stiffener may be required.

For strengthening of plate stems for navigation in ice, *see* D 1008.

308 The separate lengths of the stem are to be efficiently connected and the lower end of the bar stem is to overlap the forward flat keel plate.

Sternframes

309 Sternframes may be of rectangular or streamlined section or may be of built construction to suit the lines of the ship. The scantlings are to be determined from Tables 2 and 3 and associated notes. Cast steel and built sternframes are to be strengthened at intervals by transverse webs of suitable thickness. Cast steel stern frames are to be simple in design and all fillets should have a large radius.

310 The lower part of the sternframe is to be extended forward to provide an efficient connection to the flat plate keel.

311 The rudder post is to be attached to a transom plate of the same depth as that required for double bottom floors and ·10 inch thicker than the floors (*see* Table 6, cols. 4 and 10); when the length of the ship exceeds 300 feet, the rudder post is to be connected to the transom by double

angles, double riveted in each flange. In single screw ships having cruiser sterns or exceeding 300 feet in length the propeller post is to be efficiently attached to a deep floor.

312 The sole piece under a propeller aperture is to be kept as short as possible and is to be increased in scantlings as required by Table 2, note 4.

313 The upper gudgeon is to be as near as practicable to the rudder trunk and rudder coupling. Gudgeons are to have a thickness of metal round the finished bore equal to half the diameter of the pintle and the depth is to provide full bearing surface for the pintle. The scantlings of pintles are to be determined from Table 47 and associated notes.

314 The length of the scarph in a sternframe of rectangular section is to be three times the fore and aft dimension of the post and the width of the scarph is to be half the length of the scarph. The thickness at the tip of the scarph is to be 13 per cent of the thickness of the post, and the connection is to be made by four rows of rivets. In single screw ships the scarph of the rudder post should not be fitted above the upper gudgeon. The strength of scarphs or other connections in cast steel streamlined sternframes is to be equivalent to the above requirements.

315 The scantlings and arrangements of propeller brackets and of sternframes in ships of relatively high power will be specially considered.

Cross-reference

316 For riveted connections to stems and sternframes, *see* Table 52 H.

Section 4

SINGLE BOTTOMS

Floor Plates

401 The scantlings of floor plates are to be determined from Table 4 and associated notes. Floors are to be fitted at every frame.

If a bar keel is fitted the floors are to be continuous from side to side; if a flat plate keel is adopted the floors may be continuous or cut at the centre line.

402 The floors at the bilges are to be attached to the frames by flanged brackets of the same thickness as the floor plates and having breadth and depth, clear of the frame and floor respectively, equal to the depth of the floor at the centre line.

Alternatively, the brackets may be omitted if the depth of the floor is increased by 15 per cent and the frame is reinforced at its junction with the floor plate.

403 The tops of floors are, in general, to be level from side to side but in ships having considerable rise of floor, and in all ships in the engine room and towards the ends, the depth of the floor plates is to be increased; the brackets may be dispensed with provided the side framing is adequately supported.

404 Floor plates forming part of a bulkhead are to be not less than 36 inches in depth measured at the centre line and the thickness is to be as required for the bottom strake of the bulkhead.

405 The side frames are to be efficiently attached to the floor plates.

Frames and Reversed Frames

406 Floors are to be attached to the bottom plating by single angles having the same thickness as the floor plates. (*See* D 807.)

407 Reversed frames on the upper edges of the floor plates are to have the scantlings given in Table 4.

Throughout the engine room, under the boiler bearers and in way of strengthening of bottom forward, the reversed frames are to be doubled from side to side.

Centre Keelsons

408 The scantlings of centre keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

409 In ships having a bar keel, the centre keelson is to consist of continuous double angles on top of the floors in conjunction with intercostal plates connected to the floors by single angles having the same thickness as the intercostal plates.

In ships not exceeding 160 feet in length the intercostal plates may be omitted provided the centre keelson bars are as required by Table 5 for tugs.

410 Plate keels are to be associated with plate keelsons having double continuous top angles. The keelson plates are to be connected to the keel by single angles except in the engine room, thrust recess and the forward ·25L where the connection is to be double. If the floors are continuous the keelson plates are to be intercostal and attached to the floors by single angles having the same thickness as the intercostal plates.

Where the floors are cut at the middle line they are to be connected to the continuous keelson plate by double angles having the thickness of the keelson plates. Continuous foundation plates are to be fitted at the top of the floors on each side of the keelson plate.

411 The butts of all continuous longitudinal material are to be efficiently strapped or welded.

Side Keelsons

412 The scantlings of side keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

413 One side keelson is to be fitted on each side of the centre line if the breadth B does not exceed 30 feet and two where B is above 30 feet and does not exceed 54 feet.

414 The keelsons are to consist of a continuous angle with the wider flange faying on the reversed frames.

Intercostal plates fitted between the floors are to be attached to the continuous angles and connected to the shell plating by single angles having the same thickness as the intercostal plates.

415 The butts of the continuous angles are to be efficiently strapped or welded.

416 In the engine room additional side keelsons are to be fitted.

Increased Thicknesses in Machinery Spaces

417 In the engine room the floors are to be increased in thickness by ·04 inch.

In the boiler room the floors, reversed frames, centre and side keelson plates and all angles not covered by cement are to be increased in thickness by ·10 inch.

Strengthening of Bottom Forward

418 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading or Discharging Aground

419 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Pumping and Drainage

420 The arrangements are to be in accordance with the requirements of Chapter E. Efficient provision is to be made to permit water from every part of the bottom to reach the pump suctions.

Section 5

DOUBLE BOTTOMS

Scantlings

501 The scantlings of the double bottom structure and the tank side connections are to be determined from Tables 6 to 11 and associated notes.

Centre Girder

502 The attachment of the centre girder to the keel plate and to the middle line strake of the inner bottom is to be by double angles, or equivalent connections, throughout in all ships exceeding 350 feet in length; in smaller ships the attachment need be double, or equivalent, only in the engine room, thrust recess and in the forward ·25L.

Intercostal Side Girders

503 In ships where the breadth B does not exceed 34 feet one stiffener is to be fitted to the floors on each side, about midway between the centre line and the margin plate. Where B exceeds 34 feet one intercostal side girder is to be fitted and where B exceeds 64 feet but does not exceed 80 feet two girders are to be fitted on each side of the centre line extending as far forward and aft as practicable. In the forward ·25L of all ships side girders are to be fitted as required by D 805.

504 In the machinery space and thrust recess the number and disposition of the side girders are to be such as to support the machinery effectively and to secure the necessary rigidity of structure. Double angles or equivalent connections are to be fitted on the upper edges of these girders under the engines and thrust seating.

505 Intercostal girders are not to be flanged in the forward ·25L, under the engine and thrust seating or under widely spaced pillars. Where intercostals are flanged their thickness is to be increased by 10 per cent.

506 If plate floors are fitted at every frame the intercostal girders, except in the engine room and in the forward ·25L, may be replaced by continuous bulb angles on the shell and inner bottom, having the scantlings given in Table 10 for a span of 4 feet. These bulb angles are to be attached to the floors by vertical angles, extending for the full depth of the floors and having the same depth as the bulb angles, but these angles need not exceed 6 inches in depth. The thickness of the vertical angles may be the same as that of the floors.

Riveting at each end of the vertical angles is to be as required by Table 8, cols. 4 and 5.

Plate Floors

507 Plate floors are to be fitted at every frame in the engine room and in the forward ·25L; they are also to be fitted under the boiler bearers, bulkheads, toes of brackets to deep tank bulkhead stiffeners and in way of any change in depth of double bottom. Partial plate floors are to be fitted under the thrust seating.

The floors under the engine room, thrust seating and boiler bearers are to have double angles or equivalent attachments to the centre girder; elsewhere the connections may be single. The reversed frames on the floors may be single except under the engine room from the centre line to the girder outside the engine seating, under the thrust seating and from side to side under boiler bearers.

508 Except as required by 507, plate floors may be spaced not more than 10 feet apart, and the shell and inner bottom plating between these floors is to be supported by bracket floors. Alternatively a system of longitudinal framing may be adopted—*see* 517 to 523.

509 Floors are not to be flanged.

510 Watertight floors are to be fitted below or in the vicinity of watertight bulkheads and their thickness is to be ·08 inch greater than that given in Table 6, col. 10, but need not exceed ·54 inch. If the depth of the centre girder exceeds 36 inches the floors are to be fitted with stiffeners, of scantlings given in Table 9, spaced 30 inches apart; the ends of the stiffeners are to extend to the toes of the boundary angles.

511 Additional stiffening is to be fitted under the heels of widely spaced pillars as required by D 1516 to D 1523.

512 In ships from which the cargo is to be regularly discharged by grabs, it is recommended that plate floors be fitted at every frame.

Bracket Floors

513 The scantlings of the bottom frames and reversed frames are to be determined from Table 7 and associated notes.

514 The breadth of the brackets attaching the frames and the reversed frames to the centre girder and margin plate is to be three-quarters of the depth of the centre girder; the brackets are to be flanged on the unsupported edge and are to have the same thickness as the plate floors.

515 The frames and reversed frames are to be attached to the side girders by angles having the same depth as the reversed frames, but these angles need not exceed 6 inches in depth. The thickness of the vertical angles may be the same as that of the floors.

Struts, if fitted to reduce the unsupported span of the frames and reversed frames, are to have the scantlings given in Table 8. Where the struts are welded the area is to be at least 80 per cent of that given in Table 8, col. 6, provided their stability and end connections are adequate.

516 Details of riveted connections in bracket floors are given in Table 8.

Longitudinal Framing

517 Where longitudinal framing is adopted in the double bottom the scantlings of the longitudinals are to be as given in Table 10 and associated notes.

518 The spacing of the plate floors is not to exceed 12 feet or ·05L and the thickness of the floors is to be increased 10 per cent beyond that required by Table 6.

519 The floors are to be attached to the shell and inner bottom by double angles or equivalent for two spaces of longitudinals at each end of the floor plate. The floors are to be attached to the centre girder and margin plate by double angles single riveted, or equivalent, except where the spacing of the floors exceeds 8 feet when the attachment to the centre girder is to be by double angles double riveted.

520 The unsupported span of the longitudinals is not to exceed 8 feet. In longer spans struts of the same scantlings as required for bracket floors (Table 8) are to be introduced and attached to the longitudinals by the number of rivets given in the Table. The scantlings of the longitudinals at shell and inner bottom adjacent to the centre girder and margin plate may be based on a span of 4 feet.

The shell and inner bottom longitudinals are to be attached to the floors by means of vertical angles extending from the shell to the inner bottom having the same depth as the inner bottom longitudinals, but these angles need not exceed 6 inches in depth; they are to be riveted as required by Table 8. The thickness of the vertical angles may be the same as that of the floors.

Where longitudinals are cut at watertight floors they are to be attached to the floors by brackets of a width on each arm equal to three times the depth of the shell longitudinals, of the thickness given in Table 6, col. 10 or 11, and riveted as required by Table 8, cols. 7 and 8.

521 An intercostal side girder, as required by 503 to 505, is to be fitted on each side where B exceeds 45 feet and two side girders on each side where B exceeds 70 feet.

522 Between plate floors, transverse brackets of the thickness required by Table 6, col. 10 or 11, are to be fitted extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be flanged, are to be fitted at every frame at the margin plate and those at the centre girder are to be spaced not more than 4 feet apart.

523 Where, at the ends of the ship, the longitudinal system of framing is replaced by a transverse system adequate arrangements are to be made to avoid abrupt discontinuities.

Inner Bottom Plating and Margin Plates

524 The inner bottom plating is to be of the thickness given in Table 6 and is to be increased by ·08 inch under the hatchways if no ceiling is fitted; the thickness of the middle line strake is not to be less than that of the increased inner bottom plating.

The margin plate is to have the thickness given in Table 6 and is to be of the depth amidships required by Table 6, note 2.

525 If cargo is to be regularly discharged by grabs, or similar means, it is recommended that double ceiling should be fitted or the thickness of the plating increased ·20 inch and fitted with a flush surface.

Manholes and Lightening Holes

526 Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate ventilation and access to all parts of the double bottom and the edges of the holes are to be smooth. No manholes are to be cut in the floors or girders under widely spaced pillars.

527 Where manhole covers are attached by bolts to the inner bottom plating, doubling plates or rims are to be fitted to take the fastenings of the covers. Manhole covers which project above the inner bottom plating are to be adequately protected.

Tank Side Brackets and Margin Connections

528 The height and thickness of the tank side brackets are given in Table 11. The free edges of the brackets are to be flanged or otherwise stiffened.

At the ends of the ship where the form of the brackets may become unduly elongated, the arrangements will be specially considered.

529 Riveted attachments of the tank side brackets to the frames and margin plate are given in Table 11. The angles attaching the floors to the margin plate are to have the same number of rivets in both flanges as the angle to the tank side brackets, and the inner and outer angles are to be through riveted.

If gusset plates are fitted they are to be not more than three frame spaces apart; if the number of rivets required in the gusset is more than six per frame space the gusset is to be fitted at every frame or is to be a continuous plate. Gussets are to be so spaced that each will require not less than three rivets.

530 If the margin plate is approximately horizontal the strength of the margin connection will be specially considered.

531 For increases in the panting region, *see* D 906.

Increased Thicknesses in Machinery Spaces

532 In the boiler room and donkey boiler recess the floor plates and brackets, centre and side girders, inner bottom plating, margin plate, tank side brackets, gussets and all rolled sections not covered by cement, and in the engine room the inner bottom plating, are to be increased in thickness as required in Tables 6 to 11 and associated notes.

533 Where machinery is fitted aft, the thicknesses of the inner bottom plating in the boiler room are to be increased by the increments which would have been added if the machinery had been fitted amidships; in the engine room this thickness is to be as given in Table 6, col. 18.

Strengthening of Bottom Forward

534 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading and Discharging Aground

535 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Oil Fuel

536 If oil fuel is to be carried in double bottoms the provisions of D 2019 and D 2020 are to be complied with.

Where refrigerated cargoes are to be carried, *see* D 2021 and D 2022.

Pumping and Drainage

537 The arrangements are to be in accordance with the requirements of Chapter E.

538 Ample provision is to be made for the free passage of air and water from all parts of the tanks to the air pipes and suctions.

Caulking and Water Testing

539 The double bottom is to be caulked and made watertight, but the centre girder need not be caulked or tested.

Each compartment on completion is to be tested with a head of water representing the maximum pressure which could be experienced in service.

Cross-reference

540 For additional stiffening under heels of pillars, *see* D 1520.

Section 6

SIDE FRAMING

Scantlings

601 The scantlings of the main, peak and 'tween deck frames are to be determined from Tables 12 and 13 and associated notes.

The depth D for use in the Tables is defined in D 203.

602 The scantlings given for the framing in the various 'tween decks represent the minimum standard, but the system is to be so arranged that continuity is maintained.

603 Where holes are drilled or punched in the inboard flange of channel or similar hold frames, the scantlings may have to be increased.

Frame Spacing

604 The spacing of the frames, except in the regions defined in 605 and 606, may be as given in Tables 12 and 13.

605 Frame spacing in peaks and cruiser sterns is not to exceed the Table spacing or 24 inches, whichever is less.

606 Frame spacing between ·2L from forward and the collision bulkhead is not to exceed the Table spacing or 27 inches, whichever is less.

607 Where the spacings adopted differ from those set forth in 604 to 606, the scantlings of the main and 'tween deck frames are to be corrected as required by the notes.

Main Framing

608 The depth h to be used in Table 12 is defined in D 205, and is to be measured :

At amidships, for framing between the after peak bulkhead and ·25L from the fore end.

At ·25L from the fore end, for framing between that point and ·15L from the fore end.

As required by D 905 for framing between ·15L from the fore end and the collision bulkhead.

Framing in 'Tween Decks and Superstructures

609 In 'tween decks marked B (*see* notes to Table 13) between ·12L from the after end and ·2L from the fore end and in detached superstructures, frames may be fitted two frame spaces apart provided the main frame spacing does not exceed 30 inches and the ratio of that spacing in inches to the minimum thickness of the 'tween deck side plating does not exceed 55 in ships 300 feet or less in length and 45 in ships 500 feet or more in length, with intermediate values in proportion.

610 At each end of a bridge four frames are to extend from the 'tween deck below to the bridge deck.

611 'Tween deck and superstructure frames are to be efficiently scarphed to the main frames below or effectively attached to the deck, except in the poop where the lower ends of the intermediate frames (if fitted) need not be attached.

Cruiser Sterns

612 Cruiser sterns are to have frames of size required in peaks, and are to be additionally stiffened by web frames where required. The floor plates are to be of a reasonable depth, and are to be associated with a middle line girder.

General

613 Floors in fore and after peaks are to have a thickness ·04 inch greater than required for floors in a double bottom. In after peaks the floors are to extend well above the stern tube, or, if this is impracticable, cross-tie plates flanged on both edges are to be fitted above the stern tube. Rivets connecting floors and cross-tie plates to the frames are to be spaced not more than five diameters apart. (*See* D 908.)

614 In boiler rooms and permanent coal bunkers the thickness of the framing is to be increased ·06 inch beyond that derived from the Tables.

615 Where the depth of the framing is reduced adequate stiffness is to be maintained.

616 The breadth of the shell flange of the frames is to be suitable for the diameter of rivet used.

Cross-references

617 For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces, *see* D 19, D 20 and D 22.

Section 7

SHELL PLATING

Scantlings

701 Scantlings of flat plate keel and of garboard strakes with a bar keel are given in Table 14.

702 The thicknesses of bottom and side shell plating are to be determined from Table 14 and associated notes. The depth D for use in the Table is defined in D 203.

703 In way of an effective superstructure the thickness of bottom and side plating may be based on D measured to superstructure deck, but clear of the superstructure D is to be taken to the uppermost continuous deck. The thicker plating is to be suitably extended within the ends of the superstructure to ensure continuity of strength. (*See* 710.)

704 The scantlings of the sheerstrake are to be in accordance with Table 18 and D 1101.

Openings in Shell Plating

705 All openings in the shell plating for cargo doors, inlets, or other purposes, are to have well rounded corners, and arrangements are to be made to maintain the strength in way of the openings; the plating is to be reinforced in way of hawse pipes.

706 Where side scuttles or other openings are cut in the sheerstrake, removing more than 20 per cent of the Rule sectional area of the unpierced plate, compensation is to be provided.

Shift of Riveted Butts

707 The butts of shell plates and those of sheerstrake and stringer plates are to be arranged to give as good a shift as practicable; in adjoining strakes butts are to be generally at least two frame spaces apart.

The butts of the sheerstrake are to be at least two frame spaces from those of adjacent deck stringer plates.

Welded Construction

708 In ships having transverse framing, if the seams and butts of the bottom shell plating are flush welded and the floor angles are riveted to the bottom shell then the thickness of the bottom plating is to be increased for ·4L amidships by 5 per cent above the requirements of Table 14 and associated notes.

If the seams and butts of bottom shell plating are flush welded and the floors are welded to the shell, the thickness of the bottom plating is to be increased for ·4L amidships by 15 per cent above the requirements of Table 14 and associated notes.

In addition to the provisions of D 503, the following stiffening is to be fitted to the bottom shell for ·4L amidships with either system of construction:—

Beam not exceeding 50 ft.	Two longitudinal stiffeners, p. & s.
Beam above 50 ft. and not exceeding 55 ft.	Four longitudinal stiffeners, p. & s.
Beam above 55 ft. and not exceeding 64 ft.	Three longitudinal stiffeners, and one intercostal side girder p. & s.

Special consideration will be given to ships having greater beam.

The stiffeners are to be $6 \times 3\frac{1}{2} \times \cdot 46$ ordinary angle toe welded to the plating and connected at their ends. The intercostal side girders are to be of scantlings given in Table 6.

This stiffening, in which the engine girder system may be incorporated, is to be suitably scarphed to the stiffening forward required by D 801 and D 805, and is to be tapered gradually at the aft end.

Wood Belting

709 Wood belting and fenders are not to be through bolted to the shell plating.

Continuity of Strength

710 Continuity of strength is to be maintained at the break of superstructures as required by D 1205 and D 1305 to D 1308.

Section 8

STRENGTHENING OF BOTTOM FORWARD

Extent

801 The bottom structure is to be strengthened between ·05L and ·25L from the fore end. A sketch showing sections in way of the bottom forward is to be submitted.

Shell Plating

802 The thickness of the three strakes next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, is to be that given in Table 14, col. 10, increased by 30 per cent where the length of the ship does not exceed 450 feet and 15 per cent where the length is 650 feet; the increase at intermediate lengths to be in proportion. In ships with machinery aft not exceeding 300 feet in length the increase is to be 40 per cent and the keel plate is not to be less in thickness than the adjacent bottom plating.

The midship thickness of the above strakes is to be carried forward to the increased plating.

If the floors are welded directly to the bottom plating the latter is to be increased in thickness.

Double Bottoms

803 Floors and intercostal girders are not to be flanged.

804 Plate floors are to be fitted at every frame and are to be connected to the bottom plating by double angles, or equivalent connections, extending from margin to margin, or, in single bottom ships, to lower turn of bilge.

805 The intercostal side girders are not to be more than 7 feet apart, the plating between them being supported by additional half-height intercostal girders carried as far forward as practicable.

806 Where longitudinal framing is adopted in the double bottom the arrangements are to include plate floors fitted on alternate frames between ·05L and ·25L from the fore end and the spacing of longitudinal framing is to be in accordance with the requirements of D 606.

Single Bottoms

807 The reversed frames are to be doubled and additional intercostal girders are to be fitted; in other respects the requirements for double bottoms are to be carried out where they apply.

Riveting

808 The rivets in both flanges of the frame angles are to be spaced $5\frac{1}{2}$ diameters apart. The diameter of rivets in butts and seams of bottom plating is to be appropriate to the increased thickness of the plating, and the seams are to be double riveted.

Section 9

ARRANGEMENTS TO RESIST PANTING

Extent

901 The structure is to be strengthened to resist panting for ·15L from the fore end and abaft the after peak bulkhead.

Forward of the Collision Bulkhead

902 Tiers of beams spaced 6 feet apart are to be fitted to alternate frames below the lowest deck and are to have the scantlings given in Table 15.

903 Stringer plates of the scantlings given in Table 16 are to be fitted at each tier of beams. The stringer plates are to have double attachments to the shell plating. Alternatively, stringer plates of Table scantlings may be fitted inside the frames without attachment to the shell plating provided the stringer plate is stiffened on both edges, and the thickness of the shell plating is 10 per cent greater than the thickness given in Table 14, col. 9, where the length of the ship does not exceed 150 feet and 25 per cent where the length is 350 feet or above; the increase at intermediate lengths is to be in proportion.

904 Frames to which a beam is not fitted are to be attached to the stringer plate by brackets, having the same thickness as the beam knees and a depth of one-half the breadth of the stringer plate.

Abaft the Collision Bulkhead

905 The strength of the side frames below the lowest deck for the distance defined in 901 is to be increased 20 per cent above that derived from Table 12, the value of h for use in the Table being the maximum between ·15L from the fore end and the collision bulkhead, measured as defined in D 205.

906 The strength of the attachment of the frames to the tank side brackets, of the tank side brackets to the margin plates and gussets, and of the gussets to the margin plate is to be increased by 20 per cent above the requirements of Table 11. The connection of the floors to the margin plate is to be the same as the connection of the tank side brackets to the margin plate, and, where riveted, the connecting angles inside the tank are to be on the same side of the floor as the outside connections, to take through rivets.

907 Side stringers of the scantlings given in Table 16 are to be fitted in line with those forward of the collision bulkhead and are to extend aft for the distance defined in 901; they are to be attached to the shell by single riveted angles.

The side stringers may be omitted provided the shell plating is increased by the percentage given in 903.

Abaft the After Peak Bulkhead

908 The structure is to be efficiently stiffened by deep floors and tiers of beams in association with stringers as required in the fore peak (Tables 15 and 16) except that these may be spaced 8 feet apart. In twin screw ships the frames abaft the propeller brackets and up to the lowest deck are to be attached to the shell plating by two rows of rivets or equivalent connections. (*See* D 613.)

Special arrangements may be required in single screw ships of high speed.

If, on account of the ship's form, the unsupported length of the frames exceeds 8 feet, additional stiffening may be required.

Deep 'Tween Decks

909 If necessary, in ships with deep 'tween decks additional intercostal side stringers supported by web frames are to be fitted at the forward and after ends. The stringers may be omitted provided the thickness of the shell plating is suitably increased.

Section 10

STRENGTHENING FOR NAVIGATION IN ICE

Framing

1001 Forward of the collision bulkhead intermediate frames having the scantlings given in Table 17 are to be fitted, extending from below the level of the floors to the deck next above the load waterline.

1002 Abaft the collision bulkhead the main frames for a distance from the stem equal to ·15L are to be not less than required by D 905 to D 907 for a ship having a draught of ·06L.

Intermediate frames having the scantlings given in Table 17 are to be fitted for a distance from the stem equal to ·10L+25 feet, but this distance need not exceed 65 feet. These intermediate frames are to extend from the margin or from below the top of the single bottom floors to the deck next above the load waterline ; they need not be connected at their ends.

1003 The breadth of the shell flange of the frames is to be suitable for the riveting required by 1006.

Panting Arrangements

1004 The requirements of D 9 are also to be complied with, and the strength and stiffness of the framing system are not to be less than required for the actual draught of the ship.

Shell Plating

1005 The thickness of the shell plating is to be increased from the stem to a position as far aft as the extent of the reinforced framing between 1 foot above the load waterline and 2 feet below the light waterline.

The thickness is to be 65 per cent greater than the minimum given in Table 14, col. 11, but need not exceed 1 inch.

The shell plate in each strake immediately abaft the increased plating is to be intermediate between the full thickness required above and the normal thickness of side shell plating.

Riveting

1006 The diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by Table 52A for the increased thickness of plating. The seams of the increased shell plating are to be double riveted.

Stringers

1007 Stringers of the scantlings shown in Table 16 spaced 6 feet apart are to be fitted forward and aft of the collision bulkhead. They are to be carried aft to the position at which the shell becomes of normal thickness.

Plate Stems

1008 The thickness of the plates below the load waterline is to be 65 per cent greater than the thickness given in Table 14, col. 11, without correction, but need not exceed 1 inch; above the waterline the thickness may be tapered to that of the normal plate stem (*see* D 307). Plates which require to be furnaced are to have these thicknesses when finished. The spacing of the horizontal webs below the load waterline is not to exceed 3 feet.

Rudder and Steering Arrangements

1009 The diameter of the rudder head is to be 1 inch greater than required by Table 44. The scantlings of the rudder, the dimensions of the quadrant and tiller and the diameter of steering rods and chains are to be in accordance with the increased rudder head.

Cross-references

1010 For screw shaft and propeller, *see* H 227 and H 228.

For sea valves, *see* E 271 and E 272.

Section 11

DECKS

Plated Decks

1101 Strength deck and sheerstrake scantlings are to be determined from Table 18 and associated notes. The depth D for use in the Table is defined in D 203. Strength deck requirements are tabulated for ships having one, two or three decks. If there is more than one deck the sectional area of the strength deck given in Table 18 is that required when the scantlings of the lower decks are in accordance with Table 20.

1102 Scantlings for effective superstructures, as defined in D 206, are also to be determined from Table 18, the depth D being measured to the superstructure deck. (*See* Table 18, note 9.)

1103 Minimum thicknesses of strength decks and lower decks are given in Tables 18 and 20 respectively.

1104 Platform decks for which no credit is taken in determining the scantlings of the strength deck (*see* 1101) are to have the scantlings given in Table 20, col. 8.

Decks with Stringer and Tie Plates

1105 The scantlings of stringers and tie plates fitted under a wood deck are to be determined from Table 18, note 10, and Table 20, note 5.

Tie plates are to be fitted at each side of the hatchways and are to be continuous; where these form the upper members of girders supported by widely spaced pillars they are to be suitably increased. Cross ties are to be arranged at the ends of hatchways and other openings. The decks are to be plated over abreast machinery openings, the plating being tapered into the stringer plates beyond the openings.

Stringer Angles

1106 The butts of strength deck stringer angles are to be efficiently welded or strapped and if the angle is cut in way of scuppers compensation is to be provided.

Concentration of Loading

1107 Additional strengthening to the decks may be required where there is indication of concentration of loading.

Continuity of Strength

1108 Continuity of strength is to be maintained at the ends of large openings in the strength deck and the deck below by means of corner doubling plates or equivalent arrangements, and associated, if necessary, with intercostal girders at the strength deck. Special attention is to be given to workmanship at these parts.

For welded construction, *see* D 3106.

Wood Sheathing and Decks

1109 The material is to be of good quality, well seasoned and free from sapwood. The thickness is to be not less than $2\frac{1}{2}$ inches for pine or 2 inches for teak.

Thwartship planks are to be laid at the ends of hatchways, deckhouses and similar boundaries.

The vertical flange of coaming or foundation angles is to extend $\frac{1}{2}$ inch above the wood deck. Gutterway angles or welded flats are to be not less than ·30 inch in thickness.

The planking is to be efficiently fitted. Fastenings are to be not less than $\frac{1}{2}$ inch in diameter, sunk below the surface of the planking and covered with turned dowels, the whole being thoroughly bedded in white lead or other suitable composition.

Bolts are to be galvanised; welded studs used instead of bolts are to be coated with suitable composition before the planking is laid.

All decks are to be caulked and payed.

Deck Compositions

1110 If an approved composition is laid as a substitute for wood sheathing the steel deck is to be caulked, made watertight and coated with a suitable material in order to prevent corrosive action between the steel and the composition. The composition is to be effectively secured to the deck.

Caulking and Water Testing

1111 All plated decks are to be caulked unless sheathed with a properly caulked wood deck. The spaces between frames at lower decks are to be effectively closed by cement or other means.

Weather decks and gutterways are to be hose tested on completion.

Section 12

DETACHED SUPERSTRUCTURES

Short Superstructures

1201 The scantlings of poops and forecastles, and of bridges not exceeding ·15L in length, are to be determined from Table 21 and associated notes.

All seams and butts may be single riveted.

Long Bridges

1202 A long bridge is an effective superstructure as defined in D 206, and the scantlings are to be determined from Table 18 and associated notes. (*See* D 703 and D 1102.)

Second and third deck scantlings may be reduced in way of the superstructure. (*See* Table 18, note 9.)

1203 The riveting of butts and seams of deck plating, sheerstrake and side plating is to be as required by Table 52 B & C, but the side plating and sheerstrake seams are not to be less than double riveted for four frame spaces at the ends of the superstructure.

1204 Transverse strength is to be ensured by fitting web frames or partial bulkheads in the bridge if large deckhouses are constructed above.

Strengthening at Ends of Superstructures

1205 The thickness of the upper deck sheerstrake is to be increased by 50 per cent and the thickness of the stringer plate by 25 per cent at the ends of long bridges. Similar strengthening is to be fitted at the ends of poops or forecastles within ·5L amidships.

At the ends of short bridges these increases are to be 30 per cent and 10 per cent respectively.

In way of a long bridge the upper deck sheerstrake, stringer plate and deck plating as fitted in the wells are to extend into the bridge for a distance equal to about one-third the breadth of the ship.

The bridge side strakes, which are to be increased 25 per cent in thickness at the ends of the superstructure, are to be tapered as far as practicable into the bulwark plating or upper deck sheerstrake; the plating is to be efficiently stiffened at its upper edge and supported by web plates not more than 5 feet from the end bulkhead.

Bulkheads at Ends of Superstructures

1206 The bulkheads at the ends of poops, bridges, and forecastles are to have the scantlings and arrangements given in Table 22 and associated notes.

Deckhouses

1207 All deckhouses are to be of sufficient strength and the scantlings of the ends, sides and of the top beams are to be in accordance with the requirements of Table 23 and associated notes. Beams and stiffeners should, as far as possible, be fitted in line with the main framing.

1208 Where the length of single or two-tier deckhouses exceeds ·15L, the sectional area of the top plating is to be derived from Table 23 and associated notes. In all ships above 300 feet in length the exposed decks over passenger accommodation are to be completely plated.

1209 The sides and ends of the deckhouses are to be supported by partial bulkheads or web frames, spaced about 30 feet apart, and web frames are to be fitted, if practicable, at the sides of large openings.

Arrangements are to be made to minimise the effect of discontinuities in the deckhouse structure. All openings cut in the sides should be substantially framed and have the corners well rounded; continuous coamings are to be fitted below and above doors and similar openings.

Particular attention is to be given to the structure at the corners and ends of long deckhouses. Adequate support under the ends of the houses is to be provided in the form of web frames at ship's sides and diaphragms or pillars near the centreline in conjunction with reinforced deck beams. The corners of the deckhouses should be connected to the deck by double riveted or equivalent connections, which, if incorporating welding, will be specially considered.

The deckhouse sides are to be additionally stiffened in way of boats and the top strengthened in way of the davits.

1210 Partial bulkheads or web frames are to be fitted in the 'tween decks below deckhouses and, where practicable, in continuation of watertight bulkheads below.

Cross-reference

1211 For exposed casings protecting machinery openings, *see* D 22 and Table 23, note 11.

For scantlings of deck plating inside long deckhouses *see* Table 18, note 2 (*d*).

Section 13

RAISED QUARTER DECKS

Scantlings in way of the Raised Quarter Deck

1301 The scantlings of shell, sheerstrake, stringer and deck plating are to be based on the depth D measured to the raised quarter deck.

1302 The scantlings of side frames are to be based on the depth D measured to the upper deck with h measured to the raised quarter deck.

1303 The scantlings of beams are to be determined using the depth D measured to the raised quarter deck.

Break Bulkhead

1304 The front or break bulkhead of the raised quarter deck is to have the thickness of plating required for bridge front bulkheads and is to be sufficiently stiffened.

Strengthening at Break

1305 The stringer plates of the upper or bridge deck and the raised quarter deck are to overlap for three or four frame spaces at either side of the break bulkhead according to the size and proportions of the ship.

1306 Similarly in ships exceeding 220 feet in length the deck plating is to overlap for two or three spaces and the stringers are to extend for two or three spaces beyond the plating.

1307 Sufficient diaphragm plates, of the thickness of the break bulkhead, are to be fitted between the overlapped decks and connected to them and to the break bulkhead by double angles; the diaphragms are to be stiffened on their after edges and elsewhere if necessary.

1308 The upper deck sheerstrake is to be increased in thickness by 40 per cent and extended for a reasonable distance abaft the break. The raised quarter deck sheerstrake is also to be increased in thickness by 30 per cent when connected to a long bridge and is to be extended into the bridge.

Section 14

BEAMS AND DECK LONGITUDINALS

Scantlings

1401 The scantlings of deck beams at weather, cargo and accommodation decks are to be determined from Tables 24 and 25 and associated notes.

1402 The scantlings of deck longitudinals are to be determined from Tables 26 and 27 and associated notes.

General

1403 Beams are to be fitted at every frame.

1404 Where hatch side coamings are more than 18 inches from the deck girder the overhanging beams are to be reinforced, or the coamings are to be made sufficiently strong to act as girders to carry the ends of the beams and the load on the hatchway.

1405 Beams or longitudinals at the crown of deep tanks, peak tanks and oil fuel tanks are to satisfy the requirements of Tables 24, 25, 26 or 27 and associated notes but are not to be less in strength than the standard required for the stiffeners of the boundary bulkheads to those tanks. (*See* D 1901 and D 2004.)

1406 Where holes are punched in the face flange of channel or similar beams the modulus of the beams may require to be increased.

1407 Weather decks are to be suitably cambered.

Beam Knees and Brackets of Deck Longitudinals

1408 The scantlings of beam knees and brackets of deck longitudinals together with their riveted attachments are to be determined from Table 28 and associated notes.

1409 Where intermediate frames in the 'tween decks are omitted the beam knees are to be attached to the shell plates by angles having the same thickness as the knees.

1410 In ships having more than three tiers of beams and where large areas of deck are arranged for accommodation, or where particular conditions of loading are contemplated, the requirements for beam knees will be specially considered.

1411 The riveted attachment of half beams to hatch side coamings and casings is given in Table 52 H.

Cross-references

1412 For strong hatch end beams and deck transverses, *see* D 1512 to D 1515.

For strengthening in machinery spaces, *see* D 2207.

Section 15

DECK GIRDERS AND PILLARS

General

1501 Deck beams are to be supported by longitudinal deck girders in association with pillars or strong hatch end beams.

Deck longitudinals are to be supported between bulkheads by transverses pillared as necessary.

For the forward ·075L of forecastle and weather decks, longitudinal girders are not to be spaced more than 12 feet apart, and transverses not more than 8 feet apart. Girders are to have intercostal plates attached to the deck and are not to consist of angle runners.

Pillars in the 'tween decks and holds are to be in the same vertical line, as far as practicable.

The scantlings are to be determined from Tables 29, 30 and 31 and associated notes.

Special Loads

1502 Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased and the pillars which support the girder are to be strengthened to bear the portion of the concentrated load which they carry.

1503 Where cargoes such as chilled meat are suspended from a deck which may be simultaneously loaded above, the scantlings of the girders are to be increased as required by Table 29, note 1 (*f*).

1504 Additional attachments may be required to meet particular local stresses.

Longitudinal Deck Girders

1505 Girders are to be connected to the deck by angles of the same thickness as the web plate. If the span is greater than 30 feet in association with a normal height of 'tween deck, the deck connection is to be doubled for two beam spaces at each end.

1506 Girders of unsymmetrical section are to be supported by tripping brackets at alternate beams; if the section is symmetrical the brackets may be four frame spaces apart. Where the unsupported width of the girder flanges is 6 inches or greater the tripping brackets are to be connected to the face bar or flange. Where symmetrical sections are fitted tripping brackets are to be fitted on both sides. Intermediate beams are to be connected to the girders by lugs having the same thickness as the web plate and extending to the toe of the face bar or to the flange.

The thickness of deck plating in way of the girder is to be increased where necessary to provide an effective upper flange of the girder.

1507 Girders are to be attached to the bulkhead by flanged brackets of the same thickness as the girder. The distance of the toe of the bracket below the deck is given in Table 29 and the horizontal arm is to be the same as the depth below the girder. The connections of the bracket to the girder and the bulkhead are to be double riveted.

1508 Continuity is to be efficiently maintained over the heads of pillars, and the butts of longitudinal material in the girders are to be efficiently strapped or welded.

Hatch Coamings

1509 At lower decks side coamings acting as girders and not forming part of a continuous girder are to be extended for at least two frame spaces beyond the hatch end beams by short girders below the deck.

1510 At weather decks deep hatch coamings which are intended to act as girders are to be extended beyond the hatchway ends in the form of brackets, the coamings below the deck being effectively connected to the hatch end beams. Where extension above the deck is not practicable the coaming below the deck is to be extended by short girders for at least two frame spaces beyond the hatch end beams.

For welded construction, *see* D 3106.

1511 At the corners of all hatchways supported by hatch end beams horizontal gusset plates are to be fitted connecting the side coamings to the hatch end beams, and the vertical connections are to be double riveted or equivalent.

Strong Hatch End Beams

1512 Strong hatch end beams are to be supported at the centre line and attached to the side frames by brackets equivalent to the requirements of Table 29, and the frames are also to be strengthened if considered necessary.

1513 The hatch end beams are to be connected to the deck plating by angles of the same thickness as the web plate and sufficient tripping brackets are to be fitted.

Deck Transverses

1514 Transverses supporting deck longitudinals are to be attached to the frames by brackets equivalent to the requirements of Table 29, and tripping brackets are to be fitted as required. The transverses are to be connected to the deck by angles of the same thickness as the web plates.

1515 Longitudinals are to be attached to the transverses by lugs having the same thickness as the web plates and extending to the toe of the face bar.

Pillars

1516 Effective arrangements are to be made to distribute the loads at the heads and heels of all pillars.

1517 Solid pillars may be attached to continuous runners, having scantlings given in Table 30, fitted under the deck beams. The runners are to be attached to each beam and to the bulkheads by angle lugs having two rivets in each flange. The heads and heels of the pillars are to have a bearing fit. At watertight and oiltight surfaces the heels are to be riveted to double angles or T bars or directly welded.

1518 Tubular pillars are to be attached at their heads to suitable capital plates supported by brackets, flanged where necessary, in order to transmit the load effectively.

Doubling plates are to be fitted to the inner bottom under the heels of tubular pillars, and to decks under pillars of large diameter. The pillars are to have a bearing fit and are to be attached to the capital and doubling plates by riveted angle rings or by continuous welding.

1519 At the heads and heels of pillars built of rolled sections the load is to be well distributed by means of longitudinal and transverse brackets.

1520 In double bottoms under widely spaced pillars the connections of the floors to the intercostal girders and of the floors and girders to the inner bottom are to be suitably increased. Where pillars are not directly above the intersection of plate floors and intercostal girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in the floors and girders below the heels of pillars.

Where longitudinal framing is adopted in the double bottom equivalent stiffening under the heels of pillars is to be provided.

1521 In ships carrying refrigerated cargoes and carrying oil fuel in the double bottom, the connections of the hold pillars to the inner bottom, including the doubling plates, are to be welded. (*See* D 2021.)

1522 Where the heels of pillars are carried on a tunnel suitable arrangements are to be made to support the load.

1523 Where pillars are fitted under watertight flats the end attachments are to be sufficient to withstand the load due to water pressure.

1524 Additional pillars are to be fitted below deckhouses, windlasses, winches, capstans and elsewhere where considered necessary. The structure in way of the boat davits is to be strengthened.

1525 Arrangements for supporting the structure in machinery spaces will be specially considered.

Cross-references

1526 For centre line and bunker bulkheads supporting decks, *see* D 18.

For riveting, *see* Tables 31 and 52 H.

Section 16

WATERTIGHT BULKHEADS

Number and Disposition of Transverse Bulkheads

1601 All ships are to have a collision bulkhead, situated not less than ·05L from the fore end of the load waterline, an after peak bulkhead enclosing the stern tubes in a watertight compartment and a bulkhead at each end of the machinery space.

When a coal cross bunker is situated at the forward end of the boiler space, its after bulkhead may be of non-watertight construction as required by D 18, provided the forward bulkhead complies with the requirements of D 16 for watertight bulkheads.

If this compartment is to be used for cargo, the after bulkhead is to be welded or riveted and caulked as required by this Section, and all openings are to be blanked off and made watertight. The requirements of D 29 are to be complied with, and bilge suctions and sounding pipes fitted as required for a separate hold compartment.

1602 In ships exceeding 285 feet in length, additional bulkheads are to be fitted as follows:

Length L		Additional bulkheads	Total number
Above	Not exceeding		
feet	feet		
285	335	One, in fore hold ...	5
335	405	One, in fore hold ...	
		One, in after hold ...	6
405	470	Three	7
470	540	Four	8
540	610	Five	9

1603 Where, in ships above 220 feet and not exceeding 285 feet in length, the machinery is aft, a watertight bulkhead is to be fitted about midway between the collision bulkhead and the bulkhead at the fore end of the machinery space.

1604 The Committee will be prepared to consider proposals from Owners to dispense with one or more of these bulkheads, if they interfere with the requirements of a special trade, provided that suitable structural compensation is fitted, and a notation is made in the Appendix to the Register Book describing the number and position of the bulkheads omitted.

Height of Bulkheads

1605 The collision bulkhead is to extend to the uppermost continuous deck.

1606 The after peak bulkhead may terminate at the first deck above the load waterline provided this deck is made watertight to the stern or to a watertight transom floor.

1607 The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the ship above the second deck, when the bulkheads may terminate at that deck provided it lies above the load waterline.

In passenger ships of restricted draught the height of the bulkheads will be specially considered.

Bulkhead Plating

1608 The thickness of bulkhead plating is to be in accordance with Table 32 and associated notes.

1609 The lowest strake is to be at least 36 inches deep measured from the inner bottom, or from the keel if there is no double bottom; where an inner bottom terminates on a bulkhead the top of the lowest strake of the bulkhead is to be at least 12 inches above the inner bottom. At stokehold bulkheads in coal burning ships the lowest strake is to extend at least 24 inches above the stokehold platform.

Bulkhead Stiffeners

1610 The scantlings of vertical stiffeners having bracketed or lugged end connections are to be determined from Table 33 or 34 respectively, and associated notes. The scantlings of stiffeners which are bracketed at one end and lugged at the other may be taken as a mean between those required by Tables 33 and 34.

The scantlings for stiffeners in tugs are given in Table 35.

1611 The Tables apply to stiffeners spaced 24 inches apart at collision bulkheads and 30 inches apart at other watertight bulkheads not forming boundaries of tanks. Scantlings are to be corrected as required by the notes for departures from Table spacing.

1612 Where bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead the opening is to be suitably framed, and a tapered web plate, stiffened on its edge, is to be fitted on each side of the door from the base of the bulkhead to well above the opening.

Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, as in 'tween deck bulkheads, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration.

1613 Bulkheads are to be suitably strengthened if necessary at the ends of deck girders and where subjected to concentrated loads.

End Attachments of Stiffeners

1614 End brackets for stiffeners derived from Table 33 are to have dimensions, measured from the heel of the boundary angle to the toes of the bracket, equal to two and a half times the depth of the stiffener. The thickness of the brackets and the number of rivets required are given in Table 36.

The bracket or its connecting angle at the lower end of each stiffener is to extend to the floor adjacent to the bulkhead.

At each deck level which forms the top of a system of stiffeners plating is to be provided of a character which will ensure rigidity, and the attachments of the upper brackets on the hold stiffeners to this plating are to extend over a beam space.

Where the inner bottom is framed longitudinally the stiffeners of the bulkhead should be arranged, if practicable, over the longitudinals.

1615 End lugs for stiffeners derived from Table 34 are to be of the same thickness as the boundary angles and are to be riveted as required by Table 36.

Boundary Connections

1616 Angles connecting bulkheads to shell, inner bottom and deck plating are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

Watertight Recesses and Flats

1617 Watertight recesses in bulkheads are to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

1618 Horizontal plating is to be ·04 inch thicker than required by Table 32 for watertight bulkheads at corresponding levels. The strength and stiffness of beams are to be equivalent to the requirements of Table 33 if cut and bracketed or continuous.

The thickness of plating and scantlings of beams are not to be less than required by D 11 and D 14.

Longitudinal Bulkheads

1619 Watertight longitudinal bulkheads are to be equal in strength and stiffness to the requirements for transverse bulkheads.

Chain Lockers

1620 Chain lockers fitted abaft the collision bulkhead are to be caulked and the space is to be efficiently drained.

Riveting

1621 Requirements for riveting are given in Table 52 H.

Welded Stiffeners

1622 The scantlings of welded stiffeners will be considered in accordance with note 3 to Tables 33 to 36.

Watertight Doors

1623 Watertight doors are to be efficiently constructed and fitted, tried under working conditions and hose tested in place.

Provision should be made to ensure that coal will not impede the satisfactory operation of bunker doors.

1624 Watertight doors are to be capable of being quickly closed from an accessible position above the bulkhead deck, and are to have an index at the operating position showing whether the door is open or closed. Hand gear is to have an all-round motion. The lead of shafting is to be as direct as possible and the screw is to work in a gunmetal nut.

1625 Hinged watertight doors of approved pattern may be fitted in 'tween decks in approved positions. The hinges of these doors are to be fitted with gunmetal pins.

Caulking and Testing

1626 Watertight bulkheads, including recesses and flats, are to be caulked and hose tested on completion. At watertight flats the side frames if continuous are to be suitably collared, alternatively they may be cut and bracketed or otherwise effectively connected to the flat.

Peak bulkheads not forming boundaries of tanks are to be tested by filling the peaks with water to the level of the load waterline.

Cross-references

1627 For deep tanks, peak tanks and oil fuel bunkers, *see* D 19 and D 20.

For watertight tunnels, *see* D 17.

For machinery casings in 'tween decks, *see* D 2214.

Section 17

WATERTIGHT TUNNELS

Tunnels

1701 Where machinery is amidships the shafting is to be enclosed in a watertight tunnel large enough to permit of proper examination and repair of the shafting. A watertight door is to be provided at the forward end of the tunnel. Pipe tunnels are to have dimensions adequate for reasonable access.

Plating

1702 The thickness of plating on flat sides and curved tops of tunnels is to be determined from Table 37 and associated notes.

If the top of the tunnel is flat the plating is to be as required by D 1618 for horizontal flats of watertight bulkheads.

1703 Under hatchways the top plating is to be increased by ·10 inch, unless covered with wood not less than 2 inches in thickness which is to be secured without through fastenings in the plating.

Stiffeners and End Attachments

1704 The scantlings of stiffeners are to be determined from Table 38 and associated notes.

For flat tunnel tops the scantlings of stiffeners are not to be less than required by D 1618 for flats of watertight bulkheads.

The stiffeners are to overlap and be connected to the tunnel base angle. Angle stiffeners 6 inches in depth and all bulb angle stiffeners are to be attached to the inner bottom by lugs riveted as required by Table 36. Where welded construction is adopted equivalent arrangements are to be made.

Boundary Angles

1705 The thickness of all boundary angles is to be ·10 inch greater than the Table thickness of curved top plating given in Table 37.

Recesses

1706 The scantlings of plating and stiffeners for thrust and other recesses are to be determined as required by D 1617 and D 1618 for watertight bulkheads.

Tunnels in Deep Tanks

1707 When tunnels and recesses form boundaries of deep tanks the requirements of D 19 or D 20 are also to be complied with.

Local Strengthening

1708 Additional strengthening is to be fitted under the heels of pillars, hatch end supports or masts stepped on the tunnel. The strength of bulkheads in way of watertight doors is to be maintained as required by D 1612.

Ventilators

1709 Tunnel ventilators are to have scantlings suitable for the pressure to which they may be subjected and are to be made watertight.

Riveting, Caulking and Testing

1710 Riveting and caulking are to be as required by D 1621 and D 1626 for watertight bulkheads.

Tunnels are to be hose tested on completion.

Section 18

NON-WATERTIGHT BULKHEADS

Centre Line Bulkheads

1801 The thickness of bulkhead plating in ships exceeding 150 feet in length is to be ·30 inch in holds and ·26 inch in 'tween decks.

1802 Riveted connections of bulkheads to the decks and inner bottom are to be by single angles ·36 inch in thickness, but the attachments to the inner bottom are to be double riveted for two frame spaces at the ends of the hatchways; welded connections are to be of equivalent strength.

1803 The scantlings of stiffeners are to be determined from Table 39 and associated notes. The stiffeners may be spaced two frame spaces apart provided the frame spacing does not exceed 30 inches.

1804 Hold stiffeners are to be attached to the inner bottom by double riveted lugs or welded at their lower ends. Stiffeners at the ends of hatchways, both in holds and 'tween decks, are to have flanged brackets at top and bottom, or equivalent arrangements. Deck beams are to be connected to the stiffeners or plating of the bulkhead.

Coal Bunker Bulkheads

1805 The thickness of plating is to be as required by 1801, but the thickness of the lowest strake is to be ·36 inch; this strake is to extend at least 24 inches above the stokehold platform. Boundary angles are to be ·36 inch in thickness at the top and sides and ·40 inch at the bottom.

1806 The scantlings of stiffeners of longitudinal bulkheads which support the deck are to be as required by 1803.

1807 The scantlings of stiffeners of transverse bulkheads and of longitudinal bulkheads not supporting the deck are to be as required by Table 39, note 4.

1808 At sloping bunker casings the scantlings of stiffeners are to be suitably increased or the stiffeners are to be additionally supported by angle stays from the deck beams.

For non-watertight bulkheads at after end of cross bunkers, *see* D 1601.

Section 19

DEEP TANKS AND PEAK TANKS

Bulkheads

1901 The scantlings of plating and stiffeners of boundary bulkheads are to be determined from Tables 32 and 40 respectively, and associated notes. The plating is not to be less in thickness than ·30 inch in ships exceeding 150 feet in length. Stiffeners are to have bracketed attachments as required by D 1614.

1902 Boundary angles are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

1903 The maximum head to which the tank will be subjected is to be shown on the plans submitted for approval.

1904 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Decks

1905 The thickness of plating of a deck forming the crown of a tank is to be ·04 inch greater than that which would be required by Table 32 for plating at the same depth, corrected, if necessary, for spacing, but is to be not less than ·32 inch with beams or longitudinals spaced 24 inches apart and ·40 inch where the spacing is 36 inches, with proportionate thickness for intermediate spacing; the plating is also to satisfy the requirements of D 11.

1906 Beams are to be equivalent in strength to the stiffeners of boundary bulkheads, but are also to satisfy the requirements of D 14.

1907 Beams in deep tanks are to be supported by quarter girders, the scantlings of which are to be determined from Table 41 and associated notes but are not to be less than would be required by D 15.

1908 Pillars supporting the deck girders are to satisfy the requirements of D 1516 to D 1524.

Side Frames

1909 The modulus of side frames in deep tanks is to be increased by 15 per cent beyond the requirements of D 6.

Tunnels and Recesses

1910 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

1911 Where a complete centre line division is fitted in deep tanks the arrangements are to be as required by D 2015 and D 2016.

Ventilators

1912 Ventilators from deep tanks passing through a 'tween deck are to be strong enough to withstand the pressure to which they may be subjected and they are to be made watertight.

Riveted Connections

1913 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

1914 Tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected, but not less than 8 feet above the crown of the tanks where the depth D (as defined in D 203) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less.

General

1915 When boundary bulkheads of tanks form part of the watertight subdivision of the ship the requirements of D 16 are also to be satisfied.

1916 Tanks intended to carry oil fuel or liquid cargoes are to comply with the requirements of D 20 or D 21.

Cross-references

1917 For air and sounding pipes, *see* D 24.
For pumping and piping arrangements, *see* Chapter E.

Section 20

DEEP TANKS AND DOUBLE BOTTOM TANKS CARRYING OIL FUEL FOR SHIP'S USE

Flash Point

2001 The following requirements apply to the construction of compartments for the carriage, for ship's use, of oil fuel the close test flash point of which, as determined by a standard type of flash point apparatus, is above 150°F.

2002 When the requirements of the Rules have been complied with a notation will be made in the Register Book, except for motorships, as follows: OF (with date).

Boundary Bulkheads

2003 The thickness of plating is to be determined from Table 32 and associated notes; the plating is not to be less than ·30 inch in thickness in ships exceeding 150 feet in length.

2004 The scantlings of stiffeners are to be determined from Table 40 and associated notes. The ends of the stiffeners are to be attached by brackets in accordance with D 1614. The stiffeners are to be supported, if necessary, by horizontal girders as required by 2006 to 2009.

2005 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Horizontal Girders

2006 Bulkhead stiffeners and side frames are to be supported by horizontal girders, spaced not more than 10 feet apart, having scantlings determined from Table 41 and associated notes.

2007 The girders on bulkheads and ship's sides are to form a continuous line of support. They are to be connected at their ends by flanged brackets, having the same thickness as the web plate of the thicker girder and a length of arm, measured from the point of the bracket to the edge of the girder, equal to the width of the wider girder. If the bracket terminates on a bulkhead the length of the arms is to be equal to the width of the girder. All girders and brackets are to be double riveted or to have equivalent welded connections and the ends of the brackets are to be adequately supported.

2008 Riveted connections of girder plates to the bulkheads or shell plating are to be double for about twice the width of the girder at each end and may be single elsewhere.

2009 The girders are to be supported by tripping brackets at the toes of the end brackets and elsewhere at every third stiffener or frame. Stiffeners or frames intermediate between these brackets are to be effectively connected to the girders.

2010 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Side Frames

2011 The scantlings of side frames are to be as required by D 6, the framing depth h being measured without reference to the horizontal side girders, but the modulus may be reduced by 10 per cent where one girder is fitted or by 20 per cent where there are two girders. Where a horizontal girder is not required the modulus of the framing is to be increased in accordance with D 1909.

Decks

2012 The scantlings of decks forming the crowns of oil fuel tanks are to comply with the requirements for deep tanks given in D 1905 to D 1908.

2013 Where a steel deck abuts on an oil bunker bulkhead the deck plating is to be attached to the bulkhead either by double angles, single riveted, by a T bar, or by an equivalent welded connection. If the deck acts as a girder supporting the bulkhead stiffeners the panel of deck plating adjoining the bulkhead may require to be stiffened for this purpose.

Tunnels and Recesses

2014 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

2015 Deep tanks which extend from side to side of the ship are to have a centre line bulkhead and quarter girders.

2016 Centre line bulkheads may be intact or perforated as desired. If intact, the scantlings and arrangements are to be as required for boundary bulkheads by 2003 to 2005.

If perforated, the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads by D 19, using H measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforations is to be not less than 5 per cent nor more than 10 per cent of the total area of the bulkhead.

When brackets from horizontal girders on the boundary bulkheads abut on the centre line bulkhead a light

intercostal stringer is to be fitted at that level for the full length of the tank, or equivalent arrangements are to be provided.

Ventilators

2017 Ventilators from deep tanks, passing through a 'tween deck, are to be strong enough to withstand the pressure to which they may be subjected and they are to be made oiltight.

Watertight Subdivision

2018 When the bulkheads of oil fuel bunkers form part of the watertight subdivision of the ship, they are also to comply with the requirements of D 16.

Double Bottom Tanks

2019 Holes are not to be cut in the centre girder except in the forward and after tanks, and elsewhere where tanks are narrow due to subdivision. The centre girder need not be caulked or tested.

2020 The inner bottom plating in cargo holds where there is no ceiling is to be not less in thickness than ·34 inch when the spacing of frames or longitudinals is 24 inches and ·40 inch when the spacing is 30 inches, with proportionate thicknesses for intermediate spacing.

Seams and end laps of inner bottom plating in the engine and boiler spaces, and in the holds where ceiling is not fitted over the whole inner bottom, are to be at least double riveted.

Special Requirements for Refrigerated Ships

2021 Where the hold above a double bottom tank carrying oil fuel is used for refrigerated cargo the tank side brackets and floor plates are to be attached to the margin plate by T bars, or by welding, and gussets are to be welded to the margin plate. The connections of hold pillars, including heel doubling plates, also of the floors and intercostal plates under the pillars to the inner bottom, are to be welded. The attachments of manhole covers are not to pass through the inner bottom plating.

2022 For the requirements for protection of oiltight bulkheads, decks and inner bottom in way of refrigerated holds, *see* E 341 and E 342.

Protection and Drainage

2023 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

2024 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

2025 Where a bulkhead including its boundary connections is wholly welded, the requirements of 2024 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

2026 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than $\frac{1}{2}$ inch in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

2027 Drip trays or gutterways with suitable draining arrangements are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded, when the drip trays need only be fitted over the boilers.

2028 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Riveted Connections

2029 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

2030 All oil tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected but not less than 8 feet above the crown of the tank where the depth D (as defined in D 203) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less. The attachment of fittings to oiltight surfaces should be completed before the tanks are tested.

Workmanship

2031 The workmanship throughout is to be of the highest character and is to be submitted to close inspection. (*See* D 31 and D 32.)

Cross-reference

2032 For air and sounding pipes and the arrangements and requirements for the use of oil fuel, *see* Chapter E.

Section 21

DEEP TANKS AND PEAK TANKS CARRYING OIL AS CARGO

Oil Fuel

2101 Oil fuel having a flash point above 150° F. may be carried as cargo in deep tanks or peak tanks providing the scantlings and arrangements of the tanks are in accordance with the requirements of D 20 for oil fuel bunkers, except that the riveting may be as required for deep tanks by Table 52 H and the centre line bulkhead need not be fitted; if, however, the tanks are intended to be partially filled only, the requirements of D 20 are to be complied with in all respects.

2102 When these requirements have been carried out a notation will be made in the Register Book as follows: "Carrying Oil F.P. above 150° F. in deep and (or) peak tanks."

Vegetable and Similar Oils

2103 Vegetable oil, or similar oils, may be carried in deep or peak tanks constructed in accordance with the requirements of D 19 for ballast tanks, with the addition of a centre line bulkhead as required by D 2015 and D 2016, provided that the ventilation, drainage and control generally are as required for oil fuel bunkers.

2104 Tanks are to be designed and constructed with a view to their being cleaned with reasonable facility.

2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water by a cofferdam.

2106 When these requirements have been complied with a notation will be made in the Register Book as follows: "Carrying Vegetable Oil in deep and (or) peak tanks."

2107 Vegetable oil may also be carried in tanks complying with the requirements of 2101 and if desired the notation may be as follows: "Carrying Oil F.P. above 150° F. or vegetable oil in deep and (or) peak tanks."

2108 Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the density and nature of the cargo and an appropriate notation will be made in the Register Book.

Loading Certificates

2109 When a loading certificate is requested, before a cargo of oil is loaded the tank should be tested under pressure and examined for cleanness to ensure that it is in a proper condition to receive the oil cargo.

In special circumstances the Committee will be prepared, with the consent of all interested parties, to consider alternative arrangements in respect of the testing of these tanks.

Cross-reference

2110 For protection of oiltight bulkheads and decks in way of refrigerated holds, *see* E 341 and E 342.

Section 22

MACHINERY SPACES

Engine Seatings

2201 Built-up engine seatings are to be of ample scantlings and efficiently supported by brackets both longitudinally and transversely. The transverse brackets should be fitted over the floors and, as far as practicable, the longitudinal girders in the bottom are to be under those in the seating.

2202 If engines are bolted directly to the inner bottom the thickness of the plating under the engines is to be suitably increased.

2203 In ships having a single bottom in the engine space, the floors are to be increased in depth (*see* D 403) and the engines are to be seated on plating of substantial thickness.

2204 Additional full depth fore and aft girders are to be fitted under the engines and thrust block seatings. (*See* D 416, D 504 and D 505.)

2205 If engines are of relatively high power the strength of the structure and attachments of the seating are to be increased, special consideration being given to the power and type of engines and the relation of height of the engines to the width of the bedplate; particulars are to be submitted.

Boiler Bearers

2206 Boiler bearers are to be of substantial construction and efficiently supported by brackets. (*See* D 407 and D 507.)

Additional Strengthening in Machinery Space

2207 Additional transverse strengthening is to be provided by means of web frames and strong beams, with suitable pillaring or other arrangements.

Clearance between Bulkheads and Boiler

2208 Bunker and hold bulkheads are to be kept well clear of boilers and uptakes, and sufficient space is to be allowed all round boilers for proper access.

2209 Decks, or the tops of recesses, are to be not less than 4 feet clear of the top of the boiler. Uptakes and flat surfaces of boilers are to be not less than 18 inches, and the cylindrical shells of boilers not less than 9 inches, from coal bunker and hold bulkheads.

Protection of Decks under Donkey Boilers

2210 Decks under donkey boilers are to be increased ·10 inch in thickness and protected under coal-fired boilers by not less than 2 inches of firebrick or cement. These requirements are to extend to any part of the deck on to which fires from the donkey boiler may be drawn.

Exposed Casings Protecting Machinery Openings

2211 Engine and boiler openings on weather decks are to be protected by casings of adequate height having scantlings determined from Table 23 and associated notes. The tops of casings are to be suitably plated and stiffened.

2212 The deck openings should not be larger than necessary and suitable cross tie arrangements are to be provided.

2213 On the uppermost continuous deck of ships in which the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and on raised quarter decks, the doors in exposed casings are to be of steel. All doors are to be strongly constructed and capable of being closed and secured from both sides.

The sills of exposed doorways on the uppermost continuous deck, where the draught is as defined above, are to be 24 inches in height above the upper surface of the deck; the sills of exposed doorways on raised quarter decks are to be 18 inches and those on other superstructure decks, including those extending for the full length of the ship, 15 inches in height.

Protected Casings

2214 The plating is to be not less than ·26 inch in cargo spaces and ·20 inch in accommodation spaces in superstructures; stiffeners are to be $3 \times 2\frac{1}{2} \times$ ·26 inch angles spaced 30 inches apart. Where trunked casings form boundaries of coal bunkers they are to comply with the requirements of D 1805 to D 1808.

Skylights and Gratings

2215 Engine room skylights are to be substantially constructed and are to be securely connected to the coamings. Gratings over stokehold openings are to be protected by hinged plate covers, which are to be watertight if the level of the openings is less than 2 feet above the top of the hatch coamings required by D 2301.

Cross-references

2216 For scantlings of single bottoms in machinery space, *see* D 417.

For scantlings of double bottoms in machinery space, *see* D 532 and D 533.

For frames in boiler room, *see* D 614.

Section 23

HATCHWAYS AND DECK OPENINGS

Height of Coamings

2301 The minimum height of steel coamings above the upper surface of decks is to be as follows:—

On the weather portions of the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 24 inches.

On the weather portions of superstructure decks, including superstructures extending for the full length of the ship, for the forward ·25L ... ... 24 inches, for the remainder and on raised quarter decks 18 inches.

On decks inside superstructures where the openings in the end bulkheads have no means of closing ... 18 inches.

On decks inside superstructures where the openings in the end bulkheads are closed by strong hinged wood doors, wood shifting boards fitted in channels or portable plates secured by hook bolts ... ... 9 inches.

2302 Hatchways on other decks and in positions not detailed in 2301 are to be suitably framed.

Construction of Coamings

2303 At hatchways exposed to the weather the thickness of the side and end coaming plates is to be ·44 inch where the length L is 200 feet or greater and ·36 inch where L does not exceed 100 feet with intermediate values obtained by

interpolation. Coamings are to be stiffened on their upper edges by a substantial moulding. At hatchways below the uppermost continuous deck or within an intact superstructure the coamings are to be not less than ·40 inch in thickness.

2304 Angles connecting the coamings to the deck and the corner angles connecting the side and end coamings are to be of the same thickness as the coaming plates. Coaming angles are to extend $\frac{1}{2}$ inch above the wood deck.

2305 Side coamings of all hatchways are to extend at least to the lower edge of the beams, which are to be attached to the coamings as required by Table 52 H.

For welded construction, *see* D 3106.

2306 Hatchway side and end coamings which are 24 inches or more in height are to be stiffened by a horizontal bulb angle, or equivalent, fitted near the upper edge of the coaming; in ships 250 feet or more in length the bulb angles are to be not less than 7 inches in depth. Additional support is to be afforded by fitting brackets or stays from the bulb angle to the deck at intervals of not more than 10 feet.

2307 The scantlings and arrangements of coamings more than 36 inches in height and of coamings acting as girders will be specially considered. (*See* D 1404 and D 1509 to D 1513.)

2308 Coamings are to be made watertight above the deck and coaming angles are to be suitably turned or the coamings welded.

Hatchway Beams and Carriers

2309 Scantlings of hatchway beams are to be determined from Table 43 and associated notes.

2310 Web plate beams are to be stiffened at their upper and lower edges by double angles or welded face plates, but when bulb plates are fitted this stiffening is required at the upper edge only. The upper angles or face plates are to extend to the extreme ends of the beams.

2311 The ends of the web plates are to be flushed up on each side by doubling plates of the same thickness as the mounting angles and at least 7 inches wide. In welded hatchways beams, equivalent arrangements for stiffening the ends of the web plates are to be adopted.

2312 At beams which carry the ends of wood hatch covers the web plate is to extend well above the top of the upper angles or face plate of the hatch beams. The bearing surface for hatch covers is to be not less than $2\frac{1}{2}$ inches. (*See* 2319.)

2313 Hatchway beams are to be supported at their ends by carriers, sockets or other suitable arrangements, having a minimum bearing surface of 3 inches. Carriers formed of angles are to be not less than ·50 inch thick and one angle is to be extended down to the level of the deck. If the carriers are of a form which will not permit of extension to the deck level the coaming plate is to be increased in thickness by $12\frac{1}{2}$ per cent, or equivalent strengthening provided.

2314 The bottoms of all carriers are to be of solid construction.

2315 Sliding hatchway beams are to be provided with an efficient device for locking them in their normal positions and with means for preventing their lifting or slewing when being moved along the coamings.

Hatch Covers

2316 Hatch covers are to be fitted to the hatchways of all decks, except that at hatchways on decks as defined in 2302 the hatch covers may be dispensed with if desired by the Owners and specially approved by the Committee.

2317 The finished thickness of wood hatch covers at hatchways on weather decks, and in 'tween decks of normal height, is to be $2\frac{3}{8}$ inches for an unsupported span of 5 feet, and $3\frac{1}{4}$ inches for 6 feet 6 inches; the thicknesses for intermediate spans are to be in proportion.

When the 'tween deck height in cargo spaces exceeds 8 feet 6 inches the thickness of the covers is to be increased at the rate of 5 per cent per foot excess in 'tween deck height.

2318 The ends of all wood hatch covers are to be protected by encircling galvanised steel bands, about $2\frac{1}{2}$ inches wide and $\frac{1}{8}$ inch thick, efficiently secured.

2319 Hatch rests are to be of the same thickness as the mounting angles given in Table 43 A & B and are to provide at least $2\frac{1}{2}$ inches bearing surface for the hatch covers; they are to be bevelled if required to suit the slope of the hatches.

2320 If steel hatch covers are adopted particulars of the scantlings and securing arrangements are to be submitted.

Tarpaulins and Securing Arrangements

2321 Tarpaulins in good condition are to be provided for all hatchways requiring coamings 9 inches or more in height; not less than two tarpaulins are to be provided for all hatchways in exposed positions.

2322 Tarpaulins are to be free from jute, thoroughly waterproofed and of ample strength. The minimum weight of the material before treatment is to be 19 ozs. per square yard if the material is to be tarred, 18 ozs. if to be chemically dressed or 16 ozs. if to be dressed with black oil.

A certificate to the above effect is to be supplied by the makers of the tarpaulins.

2323 Cleats are to be fitted at all hatchways requiring tarpaulins, spaced not more than 2 feet from centre to centre, the end cleats being arranged not more than 6 inches from the hatchway corners. Cleats are to be of an approved pattern at least 2½ inches wide, with edges so rounded as to minimise the cutting of the wedges. The thickness should be not less than ⅜ inch for angle cleats and $\frac{7}{16}$ inch for smithed cleats which should be stiffened by pressing out the centre to form a web extending to the bottom of the palm. Drop forgings should be of equivalent strength. Cleats should be so set as to fit the taper of the wedges.

2324 Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not less than 8 inches in length and 2 inches in width. They should be cut on a standard taper of one in six and should be not less than ½ inch in thickness at the point.

2325 Where coamings are required to be 24 inches in height, steel bars or other equivalent means are to be provided for efficiently and independently securing each section of hatchway covers after the tarpaulins are battened down. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of covers. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashings are to be provided.

Bunker, Access and Trimming Hatchways

2326 The construction and the closing and securing arrangements of bunker, access and trimming hatchways are to comply with the requirements of 2301 to 2325 so far as applicable.

Flush Bunker Scuttles

2327 Flush bunker scuttles may be fitted on superstructure decks, including raised quarter decks.

2328 The scuttles are to be substantially constructed with screw or bayonet joints. If the scuttles are not hinged the covers are to be permanently attached by a chain.

Trunked Hatchways

2329 When hatchways are trunked through one or more 'tween decks, and hatchway beams and covers are dispensed with at the intermediate decks, the hatchway beams, coamings and covers immediately below the trunk are to be adequately strengthened; plans are to be submitted for approval.

Companionways

2330 Companions on exposed decks are to be of steel effectively secured to the deck. The height of the doorway sill is to be as required for hatchway coamings in the same position.

2331 Within the forward ·25L the doors are to be of steel and elsewhere may be of hard wood not less than 2 inches in thickness. The doors are to be capable of being operated and secured from both sides.

Section 24

VENTILATORS, AIR PIPES AND SOUNDING PIPES

Ventilation, General

2401 Ventilators are to be sufficient in number and size to provide adequate ventilation for all spaces.

Where mechanical ventilation is adopted plans showing the construction of the weather deck fittings are to be submitted for approval.

Ventilator Coamings

2402 The minimum height of ventilator coamings above the upper surface of decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 36 inches.

On superstructure decks, including superstructures extending for the full length of the ship,
for the forward ·25L ... ... 36 inches,
for the remainder and on raised quarter decks ... 30 inches.

Ventilator coamings of a greater height than 36 inches are to be specially supported and secured.

2403 The scantlings of the coamings and their attachment, if riveted to the deck plating, are to be in accordance with the following Table:—

Internal diameter of ventilator coamings		Coaming plate	Deck angle	Rivets at 4 dia. spacing centre to centre
Above	Not exceeding			
Inches		Inches	Inches	Dia.-Inches
—	8	·30	3 ×3 ×·34	¾
8	11	·32	3 ×3 ×·36	¾
11	13	·34	3½×3½×·38	¾
13	15	·36	3½×3½×·40	¾
15	17	·38	3½×3½×·42	⅞
17		·40	3½×3½×·44	⅞

2404 When the deck is sheathed with wood the vertical flange of the coaming angles is to extend $\frac{1}{2}$ inch above the wood sheathing.

2405 The deck plating in way of ventilator coamings is to be efficiently stiffened between the beams or longitudinals.

Covers

2406 All ventilator coamings are to be provided with strong plugs and canvas covers, or equally efficient appliances, for closing the openings when the cowls are unshipped.

Minor Ventilators

2407 Mushroom and gooseneck ventilators are to be strongly constructed and efficiently secured to the deck plating.

Air and Sounding Pipes

2408 Air and sounding pipes are to be fitted in accordance with the requirements of Chapter E.

2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 36 inches.

On raised quarter decks ... ... 30 inches.

On superstructure decks other than raised quarter decks but including those extending for the full length of the ship ... ... 18 inches.

2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 25

BULWARKS, FREEING PORTS, SCUPPERS, SANITARY DISCHARGES AND SIDE SCUTTLES

Bulwarks

2501 Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck, spaced not more than 6 feet apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. The plating in way of mooring pipes is to be doubled or increased in thickness.

2502 The arrangements for continuity of strength at the ends of superstructures are to be as required by D 1205. Bulwarks should not be cut for gangway or other openings near the breaks of superstructures.

2503 In welded ships, the bulwarks should be arranged to ensure their freedom from main structural stresses (*see* D 3107).

2504 The bulwarks of ships carrying timber deck cargoes are to be not less than 39 inches in height and are to be additionally stiffened at the upper edge; bulwark stays are to be attached to the deck in way of beams.

Freeing Ports

2505 Where weather decks are enclosed by bulwarks ample provision is to be made for rapidly freeing the decks from large quantities of water by means of freeing ports.

2506 The area of freeing port openings at uppermost continuous decks where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and at raised quarter decks, is to be as follows:—

Length of well	Area on each side	Length of well	Area on each side
Feet	Square feet	Feet	Square feet
15	8	55	12
25	9	65	13
35	10	75	15
45	11	85	17

On superstructures, other than raised quarter decks, but including those extending for the full length of the ship, the area of the openings is to be half the area given in the preceding Table.

In ships having deficient sheer or where there is no free passage for water across the weather deck, the freeing port area is to be suitably increased or open rails are to be fitted.

Provision is also to be made for freeing water from all open or partially open spaces in which water may be shipped and contained

2507 The lower edges of freeing ports are to be as near to the deck as practicable and the openings are to be protected by rails spaced not more than 9 inches apart.

If hinged doors are fitted over the openings their hinges are to have brass pins; fittings for keeping the doors closed are not to be provided.

Scuppers

2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down non-return valves as required by 2510.

2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

Protection of Pipes and Valves

2519 In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Side Scuttles

2520 Side scuttles and deadlights are to be of approved design and are to be made of approved material other than ordinary cast iron.

Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures are to be fitted with efficient inside deadlights permanently attached and capable of being closed watertight.

In enclosed superstructures permanently allocated to passengers or crew portable deadlights may be provided if stowed adjacent to the scuttles, provided they are accessible at all times in service.

Section 26

RUDDERS

Materials

2601 Steel castings are to comply with the requirements of P 9.

2602 Forgings made of ingot steel are to comply with the requirements of P 10.

2603 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Diameter of Rudder Head and Mainpiece

2604 The diameter of the rudder head is to be determined from Table 44 and associated notes.

2605 The mainpiece of rudders with cast or forged frames is to be of the same diameter at the top pintle as the rudder head and is to taper evenly to the heel, where the diameter is not to be less than 75 per cent of that of the head.

2606 If the supports of the rudder are so arranged that considerable bending stresses may occur in the mainpiece and head these are to be suitably strengthened.

Single Plate Rudders

2607 The thickness of plates and scantlings of arms of single plate rudders are to be determined from Table 45 and associated notes.

2608 Arms are to be arranged on alternate sides of the plate and are to be shrunk on to the mainpiece and keyed. In way of each arm the mainpiece is to be increased in diameter by 10 per cent; this increased diameter is to extend above and below the arm for a distance equal to the increase in diameter and beyond these points is to be gradually reduced to the normal diameter of the mainpiece over a distance of one-fifth of the diameter.

2609 The thickness of the key is to be 10 per cent of the normal diameter of the mainpiece at each arm, and the width is to be twice the thickness.

Double Plate Rudders

2610 The scantlings of cast or forged frames of double plate rudders will be determined in relation to their design. The thickness of the plates is to be derived from Table 46 and associated notes.

2611 The scantlings of rudders with plate frames will depend upon the arrangements adopted. The thicknesses of the outside plates and of the horizontal and vertical web plates are to be determined from Table 46 and associated notes. Special attention is to be given to the attachment of the pintles and rudder coupling to the body of the rudder.

2612 The internal surfaces of double plate rudders are to be efficiently coated and means for draining the rudder are to be provided.

Pintles

2613 The scantlings of the pintles are to be determined from Table 47 and associated notes.

2614 The distance between the top pintle and the bearing of the rudder stock should be as short as possible; where the ratio of the unsupported length to the diameter of stock is excessive the diameter of the stock may require to be increased or the length reduced by fitting an additional and accessible bearing.

2615 Where liners to pintles are fitted they are to be shrunk on to the pintles or otherwise efficiently secured.

Couplings

2616 The scantlings of couplings are to be determined from Table 48 and associated notes.

2617 The bolts are to be fitted and suitable arrangements are to be made to lock the nuts.

Riveting

2618 The diameters of rivets in rudder arms are given in Tables 45 and 46.

The rivets are to be spaced $4\frac{1}{2}$ diameters apart and the holes are to be countersunk. Where the breadth of the arm exceeds $4\frac{1}{2}$ inches the riveting is to be reeled and if the breadth exceeds 7 inches two complete rows of rivets are to be fitted, but, except at the outer ends of the arms, the rivets are not to be directly opposite to each other.

General

2619 Suitable arrangements are to be provided to prevent the rudder from lifting.

2620 When the weight of the rudder is supported by a carrier bearing attached to the rudder head the structure in way is to be adequately strengthened for that purpose. The plating under all rudder head bearings or rudder carriers is to be increased in thickness or doubled.

2621 In ships with a high astern speed the scantlings of rudder are to be specially considered.

Cross-reference

2622 For strengthening for navigation in ice, *see* D 1009.

Section 27

STEERING GEAR

General

2701 All ships are to be provided with two independent means of steering. In ships exceeding 200 feet in length one of the gears is to be operated by power sufficient to put the rudder from hardover to hardover in 30 seconds while the ship is going ahead at full sea speed. All gears are to be fitted and tested under working conditions to the satisfaction of the Surveyors.

2702 Particulars of the proposed alternative means of steering are to be submitted for approval. Hand gear of the right and left handed screw and nut type is not to be fitted in ships exceeding 300 feet in length.

2703 No additional means of steering will be required where electric or electric-hydraulic steering gear is fitted having two independent motors or sets of pumps and motors with separate leads from the source of power. With steam-hydraulic steering gears similar arrangements will be accepted.

2704 After hand steering wheel and gear in ocean going ships are to be adequately protected.

2705 The steering gear is to be secured to the seating by fitted bolts and suitable buttressing arrangements are to be provided.

Tillers and Quadrants

2706 The scantlings of tillers and quadrants are to be as given in Tables 49 and 50. Tillers and quadrants are to be shrunk on or bolted to the rudder head, in addition to being secured by a key of suitable dimensions. The keyways are to have rounded ends. The thickness of quadrant plates is to be 1 per cent of the radius given in the Table. The area of the arms at ends may be one-third of the area given in Table 49. Arms of loose quadrants not keyed to the rudder head may be of these reduced dimensions throughout their length, and the depth of the boss may be reduced by 10 per cent.

Rod and Chain Gears

2707 Steering rods and chains are to have the diameters required by Table 49 for the radius of quadrant given therein. Shackles, shackle pins, links and other connections are to be suitable for the size of chain.

2708 All steering chains are to be subjected to the breaking and proof tests for short link chains given in P 17. These tests are to be carried out at a proving establishment recognised by the Committee and the certificates are to be produced.

2709 The leads of the steering chains are to be as direct as possible and sharp bends are to be avoided. The diameters of leading block sheaves, measured at the centre of the chain, are to be not less than sixteen times the diameter of the steering chains; the pins of the sheaves are to have not less than twice the diameter of the chains.

2710 A set of spares is to be provided consisting of one complete spring buffer and one extra spring, two tested chains each equal to the longest length in the gear, two Warwick screws, four shackles, four connecting links and four rod pins.

In ocean going ships, the speed of which is 12 knots and above, one buffer spring, one Warwick screw and one length of chain may be dispensed with.

In ships engaged on short sea routes which have either a main gear which is hand operated at sea or an auxiliary gear, independent of the rods and chains, which can be effectively operated at sea, the spare gear may be confined to sufficient shackles or split links to enable repair of the gear to be readily effected in the event of its breakdown at sea. In all other ships engaged on short sea routes, the spare gear is to be as required for ships the speed of which is 12 knots and above.

Springs

2711 Springs, buffers or equivalent arrangements are to be fitted to all main steering gears.

Locking or Brake Gear

2712 An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary.

In bow rudders where a vertical locking pin is operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

Rudder Stops

2713 Stops for the rudder are to be provided and strongly secured to the deck in way of the tiller or quadrant tiller. Stops on the steering engine are to be arranged at a smaller angle of helm than those for the rudder.

Section 28

MASTS AND RIGGING

Masts and Derrick Posts

2801 The scantlings of stayed and unstayed masts and derrick posts equipped with derricks of normal outreach intended for a working load not exceeding 8 tons each are to be determined from Table 51 and associated notes. For stayed masts the Table does not provide for more than one derrick plumbing any one hatch or for two derricks working outboard; the load for use in the Table is the working load of the heaviest derrick on the mast. For unstayed masts or derrick posts, the Table provides for two derricks working simultaneously in one direction and the load to be used in the Table is the sum of the working loads of the two derricks.

2802 The scantlings and arrangements will be specially considered if desired when :

the working load of any derrick exceeds 8 tons; or

the length of a derrick exceeds the length of the mast or derrick post by more than 20 per cent; or

the derrick heel fitting is more than 8 feet above the deck; or

for stayed masts, the arrangement of standing rigging differs from that given in 2804.

2803 Masts and derrick posts are to be increased in thickness, or doubled, at the heel, deck and hounds and in way of the derrick fittings ; they are to be efficiently supported below the heel.

Standing Rigging

2804 Two shrouds, of standing rigging quality as defined in P 1803, are to be fitted on each side of stayed masts. The shrouds are to be attached at the sides of the ship at distances forward and aft of the mast each equal to one quarter of the beam of the ship or one quarter of the length of the mast, whichever is the greater. The circumference of each shroud is to be $2\frac{1}{2}$ inches where there are no derricks, 4 inches where four-ton derricks are fitted, and 5 inches where eight-ton derricks are fitted. Alternative arrangements of standing rigging will be considered in conjunction with the scantlings of the masts. Topmasts are to be efficiently stayed.

2805 Particular attention is to be paid to the strength and workmanship of all parts of the rigging and its connections. Smithwork is to be of best quality wrought iron or mild steel. The hull structure is to be effectively strengthened in way of chain plates or similar fittings. Standing rigging is to be properly set up.

Masts with Outriggers

2806 Where outriggers at mast heads are of unusual spread the scantlings of masts and rigging will be specially considered.

Cross-references

2807 For riveting, *see* Table 52 H.

For lightning conductors, *see* M 19.

Section 29

CEILING AND CARGO BATTENS

Ceiling

2901 In single bottom ships close ceiling is to be laid on the floors to the upper part of the bilges. Limber boards are to be arranged to provide easy access to the bilges.

2902 In ships having double bottoms ceiling is to be laid over the bilges and under hatchways; the ceiling over the bilges is to be arranged with hatches which are readily removable. Ceiling under hatchways may be omitted provided the thickness of the inner bottom plating in way is increased by ·08 inch.

2903 The spaces between the frames at the top of the bilge ceiling are to be closed by wood chocks and cement or other suitable means.

2904 Ceiling is to be laid either directly on the inner bottom plating embedded in a substantial composition such as Stockholm tar and cement, or on battens providing a clear space of at least $\frac{1}{2}$ inch for drainage. (*See* 2907.)

2905 The thickness of wood ceiling is to be not less than $2\frac{1}{2}$ inches in ships exceeding 200 feet in length nor than 2 inches in smaller ships.

2906 Where the covers or fittings of the manholes of the inner bottom in cargo holds project above the plating they are to be protected by a steel coaming around each manhole, fitted with a hatch of wood or steel.

Cross-references

2907 The requirements for ceiling over double bottom tanks where oil fuel is carried are given in D 2026.

2908 For ceiling in ships which are to be regularly discharged by grabs, *see* D 525.

For arrangements in way of refrigerated holds, *see* N 302 to N 304.

Cargo Battens

2909 Cargo battens are to be fitted in the holds from above the upper part of the bilge to the under side of beam knees, and in all cargo spaces in 'tween decks and superstructures up to the under side of beam knees.

2910 Wood cargo battens are to be 2 inches in thickness in ships exceeding 200 feet in length and 1½ inches in smaller ships; the clear space between the adjacent rows is not to exceed 9 inches.

2911 Battens may be dispensed with at the request of the Owners, when the classification certificate will be endorsed: "Cargo battens not fitted"; the notation "NS" will appear in the Register Book.

Section 30

PROTECTION OF STEELWORK

Cementing

3001 In single bottom ships the shell plating and framing to the upper part of the bilges are to be effectively covered with Portland or other approved cement, mixed with sand to form a suitable composition. Free edges of cement are to be of proper thickness. Clear watercourses are to be maintained throughout.

3002 In double bottoms under the boiler room the frames and shell plating are to be efficiently cemented unless the tanks are used solely for oil fuel; elsewhere inside the double bottom the cement may be dispensed with. The bilges are to be cemented or coated with a suitable composition; if cement is used it should not extend above the upper edge of the inboard flange of the margin angle.

3003 When it is desired to apply asphalt or a similar composition its use is to be sanctioned by the Owners and approved by the Committee.

Painting

3004 All steelwork not protected as required by 3001 to 3003 is to receive at least two coats of paint of suitable composition except inside tanks intended for oil; tanks not intended for oil may be coated with cement wash.

General

3005 Care is to be taken that all surfaces are thoroughly cleaned and in a suitable condition to receive the coating to be applied.

All practicable steps should be taken to ensure that the mill scale has been removed or weathered off before painting and with this in view the coating of external steelwork should be delayed as long as possible.

3006 Experience has shown that when several months elapse between the dates of launching and commissioning it is highly desirable to dry-dock ships immediately before going into service, in order to clean, examine and recoat the bottom. Experience has also shown the desirability of dry-docking for the same purpose when a ship has been about six months in service.

Section 31

WELDED CONSTRUCTION

General

3101 Where electric arc welding is to be used for the main structure the arrangement of the plating, disposition and type of joints, together with the proposed sequence of prefabrication, assembly and welding, are to be submitted for approval. The extent to which automatic welding is to be used should be indicated.

Details of welded connections of main structural members with type and size of welds are to be clearly indicated on the plans submitted for approval.

The approved arrangements, sequences and procedures are not to be departed from without approval.

3102 The structural arrangements are to be such as will admit of easy access for welding operations and will facilitate the use of downhand welding wherever possible.

The type and disposition of connections and sequences of welding are to be so planned that any restraint during welding operations is reduced to a minimum.

3103 The electrodes used are to be approved by the Committee and are to be suitable for the type of joint. The requirements for electrodes are given in P 19.

Quality of Material

3104 For ships of 300 feet in length and over, in which the seams and butts of the shell plating and strength deck are welded, steel of a quality approved under P 403 will generally be required for parts of the main structure as follows:—

For sheerstrake, stringer plate and deck plating of the strength deck within ·4L amidships when the thickness exceeds ·60 inch, except that deck plating wholly within a midship deckhouse exceeding ·15L in length and not less in breadth than ·8B and used for accommodation, need not be of a quality approved under P 403 unless the thickness exceeds ·85 inch.

For keel and bottom shell plating to upper turn of bilge within ·4L amidships when the thickness of the bottom plating exceeds ·85 inch.

Outside ·4L amidships, for sheerstrake, stringer and deck plating of strength deck at breaks of superstructures and plating at corners of openings when the thickness exceeds ·85 inch.

Special consideration will be given to cases in which a limited number of longitudinally riveted seams, although less in number than in normal riveted construction, are fitted.

When necessary the application of the above requirements to ships less than 300 feet long will be specially considered.

3105 In ships over 350 feet in length, a riveted stringer angle, or alternatively a gunwale construction incorporating steel of specially high notch toughness, may be required.

Structural Details

3106 Special attention is to be paid to structural continuity. Abrupt changes of shape or section and all sharp corners are to be avoided. The plating at corners of all openings in strength decks and shell plating is to be well rounded.

Where the deck is connected to the main hatchway coamings by welding, the deck opening and the coamings at the corners of the hatchways are to be rounded with a radius of not less than $\frac{1}{24}$ of the breadth of the opening; the minimum radius is to be 6 inches.

If the deck plating extends inside the coamings the coamings may be square at the corners, provided the side coamings are extended in the form of a tapered bracket and the deck plating at the corners is rounded as required by the preceding paragraph; the minimum radius in this case is to be 12 inches.

Where the deck is connected to the coamings by welding, the strength deck plating at the corners of all large openings is to be increased in thickness; welded doubling plates are not to be fitted. The seams and butts of the deck plating are to be kept well clear of hatch corners.

Where the deck plating stops at the coaming and is welded thereto, through penetration welds are to be used. Where the deck plating extends inside the coaming, the free edges of the plating in way of the hatchways are to be reasonably smooth and free of weld attachments.

Arrangements at the welded corners of machinery casings will be specially considered.

3107 Bulwarks, fairlead stools, mouldings, or other fittings are not to be welded to the top of the sheerstrake within ·5L amidships. The top edge of the sheerstrake is to be free of all notches and is to be reasonably smooth.

The endings of bulwarks, bilge keels or similar attachments to the hull are to be gradually tapered.

3108 Where stiffening members cross butts or seams of plating the webs of the stiffening members should be scalloped. The webs of stiffening members and bilge keels should also be scalloped at their butts.

Local concentration of welds should be avoided.

Where thick plates are butt welded to thin plates the edge of the thick plate may require to be chamfered.

3109 Individual connections part welded and part riveted are to be avoided and shall not be adopted unless specially approved.

3110 The thickness of plating may in certain cases require to be increased to take account of the greater area of panels resulting from the omission of faying flanges of the supporting structure.

Welded Joints and Connections

3111 Butt Welds Butt welds should be adopted in preference to overlaps for joints in the main structure. In general, the edges of plates to be joined by manual welding are to be bevelled on one side or on both sides of the plates to provide an included angle of from 50 to 60 degrees.

Where it is desired to adopt other forms of edge preparation full details are to be submitted for approval.

A back sealing run is to be applied to all single V butt welds and to square edge butts where main welding is carried out from one side only.

3112 Fillet Welds The dimensions of fillet welds for various structural connections are to be as required by Table 52.

3113 Tee Connections The leg length of the fillets is to be governed by the thickness of the abutting plate or web. Where the difference between the thicknesses of the parts to be joined is considerable, the size of the fillet will be specially considered.

Tee connections should be made by fillets on both sides of the abutting plate. Where the abutting plate is bevelled a sealing run should be applied on the reverse side.

3114 Intermittent Fillets The length of intermittent welds is to be measured over the correctly proportioned fillet, clear of end craters.

As an alternative to intermittent welding the scalloped arrangement shown in Table 52 G may be used where permitted by Table 52 H. (*See also* 3115.)

As a further alternative to intermittent welding, double continuous fillets may be used. These are to be of the size required for Type 3, Table 52 G, when substituted for staggered welding and Type 2, Table 52 G, when substituted for chain welding.

Intermittent fillets are to be doubled at, and carried round the end of brackets of, hold frames, longitudinals, beams, bulkhead and floor stiffeners, and of floors to shell, inner bottom and centre girder.

3115 SCALLOPS AND NOTCHES The details of scalloped construction are given in Table 52 G. All scallops are to have well rounded corners and smooth edges. Scallops are not to be cut in way of the toes of bracket connections or at other parts where stress concentrations may develop.

Scallops in side frames, longitudinals and stiffeners are to be omitted for at least 9 inches on each side of the intersection with a primary supporting member.

Notches in primary supporting members are not to be larger than necessary, and are to have well rounded corners and smooth edges. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

Additional Attachment

3116 Welded connections may be required to be increased to meet particular local stresses, or where otherwise necessary.

Overlap Joints

3117 Where overlapped joints of plating are adopted, the breadth of the overlap is to be four times the thickness of the thinner of the plates so joined, but need not exceed 2 inches.

Workmanship

3118 Welding operators are to be proficient in the type of work on which they are engaged. A sufficient number of skilled supervisors is to be provided to ensure effective control at all stages of assembly and welding operations. The welding plant and appliances are to be suitable for the purpose intended and are to be maintained in an efficient condition.

3119 Procedures for the welding of all joints are to be established for the types of electrode, edge preparation and welding position proposed. For this purpose, the surveyors may require sample tests to be prepared under similar conditions to those which will obtain during construction.

The diameter of electrode, current, voltage, rate of deposit and number of runs are to conform, as far as practicable, to those established in accordance with the preceding paragraph. Provision is to be made for checking the current in the vicinity of the arc.

3120 The preparation of plate edges is to be accurate and uniform. All joints are to be properly aligned and closed or adjusted before welding. Excessive force is not to be used in fairing and closing the work. Means are to be provided for holding the work in proper alignment without rigid restraint during welding operations.

Where excessive gaps exist between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyors.

3121 Tack welding should be kept to a minimum and where used the tack weld should be equal in quality to the finished welds. All defective tack welds should be cut out before completing the finished welds.

Care should be taken when removing tack welds and temporary fittings used for assembly to ensure that the material of the hull is not damaged.

3122 The surfaces of all parts to be welded are to be clean, dry and free from rust, scale and grease. The surfaces and boundaries of each run of deposit are be to thoroughly cleaned and free from slag before the next run is applied.

Before a sealing run is applied to the back of a weld, the original root run is to be cut back to sound metal.

Welding is to proceed systematically, each welded joint being completed in proper sequence without undue interruption.

Adequate protection is to be provided where welding is required to be carried out in exposed positions in wet, windy or cold weather. In cold weather precautions should be taken to screen and pre-warm the work to prevent too rapid cooling of the weld; special care is necessary when welding thick material.

3123 All finished welds are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Care is to be taken to ensure thorough penetration and fusion.

3124 Where the structure embodies both welding and riveting, welded joints are in general to be completed before riveting in their vicinity.

Inspection

3125 Effective arrangements are to be provided for the inspection of finished welds, in order to ensure that all welding has been satisfactorily completed.

Visual inspection may require to be supplemented by other forms of non-destructive crack or flaw detection methods for the examination of important structural welds. A system of radiographic examination should be used wherever practicable, and where this is available the Surveyors are to collaborate with the builders in this system of inspection.

All defective sections of welds are to be cut out and carefully rewelded.

3126 Alternative proposals for methods of welding considered by the Committee to be equivalent to those set forth in the Rules will be accepted.

Section 32

RIVETED CONSTRUCTION

Riveted Connections

3201 The requirements for riveted connections and the diameter and spacing of rivets in the various parts of the structure are given in Table 52. The diameter of the rivets is to be regulated, in general, by the greater thickness of the parts to be connected, but where the difference is considerable special consideration will be given. (*See also* Notes to Table 52.) Where frame spacing wider than that given in the Tables is adopted the diameter and the number of rows of rivets are to be regulated by the thickness of the plating required at the Table frame spacing.

3202 The breadths of the flanges of connecting angles or other sections are to be generally not less than four times the diameter of the rivet for rivets up to $\frac{7}{8}$ inch in diameter and three and one-half times for rivets of 1 inch diameter or over.

3203 Chain riveting is to be adopted for the butts and seams of plating. In the connections to bar keels, stems and sternframes and in double riveted stringer angles, boundary angles and frame connections the rivets are to be reeled.

Form of Rivets

3204 Rivets are to be suitably formed to fill the rivet holes completely. Where the holes have been punched the rivets are to be increased under their heads. The heads of pan headed rivets are to have a depth of ·7 and a diameter at the bottom of the head of 1·6 times the diameter of the rivet. Where countersunk headed rivets are used the heads are to be suitable for the countersinking of the material.

Countersinking

3205 Rivet holes are to be countersunk on the caulking side of plating, and in boundary connections, of shell, weather decks, inner bottom, double bottom tank ends, crowns and bulkheads of peak tanks, deep tanks and oil fuel bunkers. The holes in the margin plate to take gusset plate rivets are also to be countersunk.

3206 The countersinking of the holes is to extend through at least nine-tenths of the thickness of the plates or angles where the thickness does not exceed ·50 inch and through at least eight-tenths where the thickness is above ·50 inch.

3207 The angle of countersink for material not exceeding ·50 inch in thickness is to be about 60 degrees; for plating exceeding this thickness the angle is to be about 45 degrees.

Workmanship

3208 Workmanship is to be well executed and submitted to close inspection throughout the preparation and building of the ship. The various parts of the structure are to be faired and properly closed.

3209 Punches, dies and shears are to be maintained in good condition and the clearance between the punch and the die is to be kept as small as possible.

Plating

3210 The preparation of plate edges is to be accurate and uniform. Shearing is to be carried out from the faying surface wherever practicable. Any burr on plates or sections preventing the closing of work is to be removed.

3211 All caulking edges are to be planed, flame cut, chipped fair, or otherwise suitably prepared.

Liners and Joggling

3212 Where plates or sections are joggled care is to be taken that the joggle is of the correct depth and rivet holes are to be clear of the joggle.

3213 Liners, if fitted, are to be in one piece of the proper thickness and of breadth not less than the flange of the faying section. Holes in liners are to be of the same diameter as those in the plate and section.

Riveting

3214 Rivet holes may be drilled or punched and are to be countersunk where required by 3205 to 3207. Punching is to be carried out from the faying surface wherever practicable.

3215 Any burr caused by drilling or punching is to be removed before the work is closed for riveting.

3216 Unfair rivet holes are to be remedied by reamering and rivets of an appropriate diameter are to be used. Where necessary the holes are to be recountersunk and the faying surfaces cleaned.

3217 Rivet holes in the frames at the turn of the bilges and at bossing are not to be drilled or punched to their full diameter before the frames have been shaped.

3218 Service bolts of requisite size and number are to be used to hold the parts in position and in close contact.

3219 The heads of the rivets are to be properly laid up and the work performed so that the holes are completely filled. Points of rivets are to be kept full but are not to be spread over the plating. In holes which are not countersunk the rivets are to be finished with specially full or snap points.

3220 Rivets in all parts are to be spaced to ensure the efficient closing of work. Particular care is to be taken with three-ply riveting.

Caulking

3221 Caulking is to be thoroughly executed. Stop-waters of suitable material may be fitted where necessary; otherwise the use of soft packing is to be kept to a minimum. Thick packing is not to be used.

Oil-tight Riveted Work

3222 The requirements of 3201 to 3221 are to be complied with.

3223 Faying surfaces are, in general, to be fitted steel to steel; but where packing is necessary the material used is to be as thin as possible and not soluble in oil.

3224 Where there may be difficulty in securing fairness rivet holes are to be drilled in position or punched small and reamered.

3225 Where boundary angles are double both flanges of each bar are to be caulked and countersunk headed rivets are to be used.

3226 Where fitted on caulking surfaces angle or T-bar connections are to be caulked.

3227 Attachments of fittings are to be made as far as possible without piercing the plating; where through fastenings are necessary they are to be tapped and efficiently secured to the plating.

Section 33

EQUIPMENT

General

3301 The regulations governing the assignment of the figure 1 for equipment are contained in B 201 and B 202.

3302 To entitle a ship to the figure 1 the equipment is to be in accordance with the following requirements and Table 53. For ships engaged on a special or restricted service an equipment less than the Table requirements may be approved by the Committee if considered suitable for the particular service on which the ship is to be engaged.

Equipment Number

3303 The equipment of anchors, chain cables, wires and ropes given in Table 53 and associated notes is based on an "Equipment Number" which is to be the sum of the numbers calculated as follows:—

For the Hull:—

$$\text{Number} = L(B+d) + 0.85\,L(D-d)$$

(For definitions of L, B, D and d *see* D 201 to D 204; D is to be measured to the uppermost continuous deck.)

For Superstructures, i.e., for those parts of the structure which extend athwartships to the side of the ship or are set inboard not more than 12 inches; also for continuous trunkways:—

$$\text{Number} = 0.85\,(l \times h)$$

where l=overall length of superstructure, including rounded ends, in feet,

h=height from deck to deck, in feet.

Projections beyond the length l, i.e., structure not extending to, or within 12 inches of, the side of the ship may be treated as Other Erections. (*See* below.)

Where promenade spaces are enclosed by screens at the side of the ship, the length so enclosed is to be treated as superstructure.

For Other Erections:—

$$\text{Number} = \cdot 75\ (h \times l)$$

where h=height, in feet,

l=overall length, in feet.

The following need not be included in computing the number:—

All parts outside the length L.

Isolated erections when both length and breadth are less than one-half B.

Hatch coamings unless forming part of a continuous trunkway.

Anchors

3304 Anchors are to be of approved design. The heads of stockless anchors, including pins and fittings, are not to be less than 60 per cent of the total weight of the anchor. Where anchors with stocks are provided the weight of the stock is to be 25 per cent of the total weight of the anchor including shackle, etc., but excluding stock.

Chain Cables

3305 The form and proportions of the links and shackles are to be in accordance with recognised practice.

Testing of Equipment

3306 All anchors and chain cables are to be tested at establishments and on machines recognised by the Committee or controlled by a Government, municipal or similar responsible body, and in accordance with the requirements of P 15, P 16 and P 17.

Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the ship.

3307 The notation "LACP" will be entered in the Appendix to the Register Book when the anchors and chain cables have been tested at licensed proving establishments in Great Britain or have been tested under the supervision of the Society's Surveyors at other proving establishments on machines recognised by the Committee.

3308 When the anchors and chain cables have been tested on a machine controlled by a Government, municipal, or similar responsible body in accordance with the Rule requirements, although not under the supervision of the Society's Surveyors, and test certificates signed by a competent authority are produced for the Surveyor's examination and verified, the equipment will be accepted, but the notation "LACP" will not be made in the Appendix to the Register Book.

3309 Anchors and chain cables supplied to ships registered in the United Kingdom are required by statute to be tested at a licensed proving establishment in Great Britain.

3310 Steel wire ropes are to be tested as required by P 18.

Arrangements for Working and Stowing Anchors and Cables

3311 A windlass of sufficient power and suitable for the size of chain cable is to be fitted and efficiently bedded and secured to the deck. The thickness of the deck in way of the windlass is to be increased and adequate stiffening is to be provided, to the Surveyor's satisfaction.

3312 An easy lead of the cables from the windlass to the anchors and chain locker is to be arranged.

3313 Hawse pipes are to be of ample thickness and of a suitable size and form to house the anchors efficiently. Substantial chafing lips are to be provided at the shell and deck. The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

3314 The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain or spurling pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to be separated by a division in the locker, and provision is to be made for securing the inboard ends of the cables to the structure.

3315 Satisfactory arrangements are to be made for the stowage and working of the stream anchor if provided.

Cross-reference

3316 For the equipment of tugs, *see* D 3511.

Section 34

RECOMMENDATIONS IF ADDITIONAL STRENGTHENING FOR HEAVY CARGOES IS DESIRED

General

3401 The following recommendations are inserted for the guidance of Owners who desire to provide additional strengthening to ships regularly engaged in onerous heavy cargo trades.

3402 The scantlings, arrangements and equipment should be as required by Sections D 1 to D 33, modified as follows.

Structural Design

3403 The double bottom and strength deck should be longitudinally framed.

Double Bottom Structure

3404 PLATE FLOORS Under cargo holds abaft ·25L from forward plate floors should be fitted on alternate frames in way of the hatchways, but may be on every third frame, with maximum spacing of 8 feet, clear of hatchways.

3405 INNER BOTTOM LONGITUDINALS The section modulus of the inner bottom longitudinals should be derived from Table 10 and associated notes for the maximum span and increased by 10 per cent.

Struts should not be fitted to the longitudinals between the floors.

3406 CENTRE GIRDER When the maximum spacing of the plate floors is 8 feet, the height of the centre girder should be increased 20 per cent above that required by Table 6; when the maximum spacing of floors is 6 feet or less, the height of the centre girder may be as required by Table 6.

3407 SIDE GIRDERS Side girders should not be less than required by D 503.

3408 INNER BOTTOM PLATING The thickness of the inner bottom plating should be increased by ·20 inch above the requirements of Table 6 or alternatively double ceiling should be fitted.

Side Framing

3409 In the holds the height of the tank side brackets above the tank top as required by Tables 6 and 11 should be maintained. The arms of the lower deck beam knees should be increased by 6 inches and the riveting correspondingly increased. The frames and beams should not be reduced in size on account of this increase.

Decks

3410 The sectional area of the strength deck plating as derived from Table 18 and associated notes should be increased by 10 per cent for ·4L amidships.

3411 STRONG HATCH SIDE COAMINGS AND END BEAMS UNDER CARGO DECKS The scantlings should be determined by the numeral derived from the notes to Table 29 increased by 10 per cent.

Section 35

TUGS

General

3501 The scantlings and arrangements of tugs are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d, used for determination of scantlings, is not to be less than ·85 D.

Class

3502 Tugs built in accordance with the requirements of this Section will be classed 100A1 with the class notation "For Towing Services."

3503 Where tugs are intended for service in sheltered waters only, the class will be A1 "For Towing Services" with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved by the Committee.

Floors

3504 Floors in tugs having single bottoms may be flanged $3\frac{1}{2}$ inches on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reversed frames are to be fitted as required by D 407.

Keelsons

3505 The scantlings of keelsons are to be in accordance with the requirements for tugs given in Table 5.

Bulkheads

3506 Watertight bulkheads are to be constructed generally as required by D 16, but the stiffeners may be determined from Table 35.

Machinery Casings

3507 Machinery casings are to be not less in height than 3 feet above the upper surface of the deck.

Casings extending to the bottom of the beams are to be connected to the beams; the deck connection may be made by a single riveted angle or equivalent. If the casings do not extend to the bottom of the beams the casing connection to the deck is to be double riveted or equivalent.

3508 Machinery casings are to be made watertight and hose tested.

3509 A strong through beam is to be fitted at the deck level between the engine room and boiler room openings. A through beam should also be fitted in motor tugs when the machinery opening is of considerable length, and the casing stiffened by webs.

Panting and Strengthening of Bottom Forward

3510 The arrangements to resist panting, required by D 9, do not apply to tugs below 150 feet in length. In tugs 150 feet or more in length additional stiffening is also to be fitted in the 'tween decks throughout the panting region.

The requirements of D 8 for strengthening of bottom forward do not apply to tugs.

Equipment

3511 The regulations governing the assignment of the figure 1 for Equipment are defined in B 201 and B 202. The equipment is to be determined from Table 54 and associated notes. The equipment numeral is to be L (B+D) without addition for casings or other erections. (*See* D 3303.)

21st April, 1955

PETROLEUM TANKERS

Section 40

GENERAL

Application

4001 The class 100A1 with class notation "Carrying Petroleum in Bulk" will be assigned in accordance with the provisions of Chapter B to all sea-going petroleum tankers when the requirements of the relevant rules have been complied with.

The scantlings and arrangements of tankers intended for liquid cargoes in bulk, other than petroleum, will be specially considered in relation to the nature, density and temperature of the cargo to be carried. In such cases the class notation may be suitably modified.

Sections D 1 to D 33 apply to tankers except as otherwise required by the following Rules.

Method of Construction

4002 The following Rules and Tables set forth requirements for welded construction with certain modifications when riveting is adopted.

Structural Design

4003 The following Rules are intended for single deck tankers having two longitudinal bulkheads, with the machinery aft, and framed in the cargo tank spaces either on the longitudinal system at bottom, sides, deck and longitudinal bulkheads, or alternatively, on the combined system with longitudinal framing at the bottom and deck, and transverse side framing and vertical stiffening on the longitudinal bulkheads.

Approval will be given for other systems of construction or arrangements if these are considered equivalent to the Rule requirements.

If the proportion of length to depth exceeds fourteen, or the ratio of breadth to depth is extreme, or the ratio of tank space to length of ship is abnormally low, specially increased scantlings will be required.

Quality of Material

4004 Where the seams and butts of the shell plating and strength deck are welded, steel of a quality approved under P 403 will generally be required for the main parts of the structure as follows:—

For sheerstrake, strength deck stringer and deck plating, bottom plating from keel to upper turn of bilge, within ·5L amidships, also for sheerstrake stringer and deck plating at breaks of superstructures outside ·5L amidships, when the thickness of the plating exceeds ·80 inch.

Where the bottom plating is required to be steel of the above quality, the keel plate is also to be of the same quality.

In tankers over 350 feet and not exceeding 475 feet in length, the connection of the stringer plate to the sheerstrake should be riveted.

In tankers over 475 feet and not exceeding 550 feet in length the connection of the stringer plate to the sheerstrake and the seams of the bilge strake should be riveted.

In tankers over 550 feet and not exceeding 600 feet in length an additional longitudinal riveted connection should be arranged in the bottom shell and in the upper deck, in the vicinity of the longitudinal bulkheads.

In ships over 600 feet in length, in addition to the above requirements, the lower edge of the sheerstrake should be riveted.

Alternatively, all-welded construction incorporating strakes of steel of specially high notch toughness in the locations mentioned above may be accepted.

Steels approved for this purpose must comply with the Society's prescribed specifications and production tests for high notch tough steel.

Length of Tanks

4005 If the length of any oil tank exceeds 35 feet the scantlings and arrangements of the boundary bulkheads will be specially considered.

Cofferdams

4006 Cofferdams are to be provided at the forward and after ends of the oil cargo spaces unless these are separated from the ends of the ship by a pump room; cofferdams are to be at least 3 feet in length and are to cover the whole area of the end bulkheads of the cargo spaces.

Superstructures

4007 A forecastle of not less than ·07L in length is to be fitted.

The machinery space is to be protected by a poop of sufficient length to cover the machinery casings, or the poop may be dispensed with provided the machinery casings are protected by a deckhouse of equivalent strength.

The height of superstructures is to be at least 6 feet where L is 250 feet or less and 7 feet 6 inches where L is 400 feet or more, with intermediate values in proportion. (*See* D 45.)

Freeing Arrangements and Gangway

4008 Ships with bulwarks are to have open rails fitted for at least half the length of the exposed part of each well.

A strong, permanent fore-and-aft gangway is to be fitted at the level of the superstructure decks.

Rudder

4009 The diameter of the rudder head and of the pintles is to be increased by 10 per cent above the requirements of D 26. The remaining scantlings of the rudder are to be based on the increased diameter of the rudder head; the quadrant, tiller and steering gear need not be similarly increased.

The requirements of D 1009 for navigation in ice are to be applied only where they exceed the above increases.

Submission of Plans

4010 In addition to the plans required by D 108, plans showing the construction of the transverse and longitudinal oiltight bulkheads, end connections for all longitudinals and other framing members, the structure at the ends of the ship, deckhouses protecting machinery casings and arrangements at the junction of transverse and longitudinal framing are also to be submitted.

Definitions

4011 The Draught d for use in the Tables is to be the summer draught in feet measured from top of keel, but should not be less than $\cdot 85D - \cdot 0025D^2$. In computing the freeboard for use in the Tables, a bridge set in not more than 12 inches from the ship's side may be taken into account.

Strength Deck is the continuous deck irrespective of the superstructures above that deck.

Equipment

4012 Equipment is to be as required by D 33, but for ships without sheer in way of ·5L amidships the depth for the equipment numeral may be taken as 97½ per cent of the depth moulded amidships.

Section 41

TRANSVERSES AND WEBS, STRINGERS AND GIRDERS

Bottom and Side Transverses

4101 The scantlings of bottom transverses are to be derived from Table 60 and associated notes.

4102 The scantlings of side transverses which support longitudinals or side stringers but which are not supported by cross ties are to be derived from Table 60 and associated notes.

4103 The scantlings of side transverses which support longitudinals or side stringers but which are supported by cross ties are to be derived from Table 63 and associated notes.

4104 If it is desired to taper side transverses the mean depth is to be derived from Table 60 or 63 and associated notes; the increase in depth at the bottom and the decrease at the top are not to exceed 10 per cent of the mean depth.

4105 Side transverses are to be fitted in ships of 35 feet depth or over having the side shell and longitudinal bulkheads vertically framed where either the proportion B/D exceeds 1·75 or the spacing of the transverse bulkheads exceeds 32 feet.

Deck Transverses

4106 The scantlings of deck transverses are to be as required by Table 61 and associated notes.

Vertical Webs on Longitudinal Bulkheads

4107 The vertical webs on longitudinal bulkheads are to have the same scantlings as the transverses at the ship's side, but the thickness of the web plates may be reduced by 10 per cent. Vertical webs may also be tapered as permitted for side transverses by 4104.

Vertical Webs and Horizontal Girders on Transverse Bulkheads

4108 The scantlings of vertical webs and horizontal girders on transverse bulkheads are to be derived from Table 64 and associated notes.

Side Stringers and Horizontal Girders

4109 Side stringers for the support of transverse framing are to be fitted as required by Table 69 and the scantlings are to be derived from Table 64 and associated notes. Horizontal girders are to be fitted at the same level to support the vertical stiffeners of the longitudinal bulkheads; the scantlings of these girders are also to be derived from Table 64 and associated notes. In ships where webs are not fitted the lower side stringers and horizontal girders are to be supported by suitable buttress brackets from the bottom transverses.

Cross Ties

4110 Cross ties may be of plate or sectional material, but they are to be of such a form as to provide sufficient stiffness in all directions.

Scantlings are to be derived from Table 66 and associated notes.

Cross ties are to be connected to the vertical webs or to the horizontal girders by suitable brackets in order to spread the load.

Centre Line Girders

4111 An intercostal girder effectively connected to the transverses and bulkheads, and having scantlings derived from Table 62 and associated notes, is to be fitted at the centre line to support the keel when docking. Flanged or otherwise stiffened brackets are to be fitted on both sides of the girder not more than 6 feet apart with intermediate vertical stiffeners, or equivalent arrangements are to be provided.

If the centre line girder is intended to support the bottom transverses, it is to be continuous between transverse bulkheads and to have scantlings derived from Table 60 and associated notes.

4112 A centre line girder is also to be fitted in association with the transverses under the deck. The girder is to be suitably stiffened and supported, and to have scantlings derived from Table 65 and associated notes.

Cross-reference

4113 For structural details and connections, *see* D 49 and Table 76.

Section 42

BOTTOM, SIDE AND DECK FRAMING

Bottom, Side and Deck Longitudinals

4201 The scantlings of bottom and deck longitudinals are to be derived from Table 67 and associated notes.

4202 The scantlings of side longitudinals are to be derived from Table 68 and associated notes.

4203 The scantlings of bilge longitudinals are to be graduated between those required for the bottom and side longitudinals.

4204 The spacing of transverses is not to exceed 12 feet and longitudinals are to be connected to them as required by Table 76 E.

4205 End connections of longitudinals to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of longitudinal strength.

Transverse Side Frames in Cargo Tanks

4206 The scantlings of side frames are to be derived from Table 69 and associated notes.

4207 Side frames are to be connected to horizontal girders as required by Table 76 E.

4208 The brackets at the upper end of side frames are to be as shown in Table 76 F.

4209 Side frames are to be efficiently connected at the lower end to stiffened brackets covering the entire round of bilge and extending at least to the first bottom longitudinal. The thickness of the brackets is to be that required for the transverses in the wing tanks.

4210 Side frames are to be reinforced by side transverses where required by D 4105.

Section 43

SHELL PLATING

Scantlings

4301 The thicknesses of the keel, shell plating and sheerstrake are to be derived from Table 70 and associated notes. (*See* D 4706.)

Openings in Shell

4302 Sea inlets in pump rooms are to be fitted, if practicable, clear of the bilge radius and so arranged as to avoid discontinuity of transverse frames, longitudinals or bilge keels. The plating in way of the inlets is to be increased in thickness or doubled and if the openings are not circular or oval the corners are to be rounded with as large a radius as practicable.

Continuity of Strength

4303 Continuity of strength is to be maintained at the break of the poop and at the ends of the bridge as required by D 45. Effective stiffening and support to shell plating are to be provided in cofferdams and pump rooms.

The upper edge of the sheerstrake is to be dressed smooth and kept free of isolated welded fittings, connections, or scupper openings above the deck involving local discontinuities. Bilge keels and their shell connections are to be gradually tapered off at their ends and scalloped at their butts and at the butts of shell plating.

Section 44

DECKS

Scantlings of Strength Deck

4401 The thickness of the strength deck stringer and plating and the scantlings of the stringer angle, if fitted, are to be derived from Table 70 and associated notes.

4402 The midship thicknesses are to be maintained for ·5L amidships, and scantlings in way of the fore end of the poop are to be as required by D 4504 and D 4505. When the machinery opening extends forward beyond a point one-third of the breadth B abaft the poop front, deck scantlings will be specially considered.

4403 The scantlings of stringer angles determined from Table 70, col. 16 and note 6, are to extend throughout the cargo spaces and at least one-third of the breadth B within the poop. At the ends of the ship the scantlings of stringer angles are to be determined from Table 19.

Scantlings of Lower Decks

4404 The scantlings and arrangements of lower decks are to be as required by D 11, D 14 and D 15.

Continuity of Strength

4405 The strength deck stringer plate is to be increased in thickness at the ends of superstructures as required by D 4504.

4406 Abrupt discontinuities at the ends of lower decks and flats are to be avoided by suitable tapering of the stringer plates or by fitting large brackets.

4407 The corners of all deck openings are to be well rounded and smooth, and strength is to be maintained in way of pump room entrances or other openings.

4408 If the stringer angle is cut at the scuppers compensation is to be provided.

Cross-reference

4409 For decks of superstructures, *see* D 4501 to D 4503.

Section 45

SUPERSTRUCTURES

Scantlings

4501 The scantlings of the bridge and forecastle are to be as required by Table 21 and associated notes, and the scantlings of the poop are to be as required for a bridge.

4502 When the side of the bridge is set in from the ship's side not more than 12 inches the scantlings are to be as required for a bridge.

4503 The scantlings of midship deckhouses are to be as required by 4511 to 4513.

Strengthening at Ends of Superstructures

4504 The thicknesses of the sheerstrake and strength deck stringer plate are to be increased by 20 per cent at the break of the poop and at the ends of the bridge, except that if the bridge does not extend to the ship's side the sheerstrake need not be increased.

4505 The midship thickness of the strength deck plating is to extend into the poop for a distance at least equal to one-third of the breadth B.

4506 The thickness of the poop side plating is to be increased by 20 per cent at the fore end.

4507 The bridge and poop side plating is to be extended beyond the ends of these superstructures and tapered into the bulwark or sheerstrake; the extended plating is to be effectively supported. Where connections at these parts are welded, arrangements are to be made to ensure an easy sweep and the absence of any local discontinuity at the junction with the main structure.

End Bulkheads

4508 The bulkhead at the fore end of the poop is to have the scantlings required by Table 22 and associated notes, but if any part of the bulkhead forms the fore end of the machinery casing the stiffeners in way are to be spaced 24 inches apart and are to be bracketed at top and bottom or are to have equivalent end connections.

4509 Openings in the poop front are to have sills not less than 18 inches in height.

4510 The end bulkheads of the bridge and forecastle are to comply with the requirements of Table 22 and associated notes.

Midship Deckhouses

4511 If a deckhouse is fitted on the strength deck amidships in place of a bridge, the scantlings are to be derived from Table 22 as indicated in 4512 and 4513.

4512 The front bulkhead is to be plated and stiffened in accordance with the requirements of Table 22 "Bulkheads at the fore end of bridges, of unprotected poops the length of which is ·4L or more and of all poops protecting machinery openings," but the stiffeners are to be bracketed at top and bottom; the modulus of stiffeners may be reduced by 20 per cent.

4513 The side bulkheads are to be plated and stiffened in accordance with the requirements of Table 22 "Bulkheads of poops partially protected or less in length than ·4L and not protecting machinery openings," but the thickness of the plating is to be increased 10 per cent.

The after bulkhead is to be plated in accordance with the requirements of Table 22–"Bulkheads of poops partially protected or less in length than ·4L and not protecting machinery openings"–and the modulus of the stiffeners may be 70 per cent of the requirements of this Table.

Exposed Machinery Casings

4514 Exposed machinery casings on the poop deck are to have the scantlings given in Table 23 lower tier, without correction for draught, but the modulus of the stiffeners is to be increased by 50 per cent and the thickness of the plating by 30 per cent. The doors are to be of steel, permanently attached and capable of being operated from both sides; the sills of the doorways are to be 15 inches above the deck.

Pump Room Entrances

4515 Houses protecting openings to pump rooms are to be strongly constructed. The doorways are to have 24 inch sills and are to be closed by hinged steel watertight doors.

Section 46

OILTIGHT BULKHEADS

General

4601 Longitudinal bulkheads are to be oiltight throughout the cargo tanks but the plating may be perforated in cofferdams and also in pump rooms, provided suitable compensation is arranged.

Beyond the ends of the oil compartments the bulkheads are to scarph into the adjoining structure.

4602 For the arrangement of cofferdams, *see* D 4006. The strength and stiffness of cofferdam bulkheads are to be as required for oiltight bulkheads.

4603 For the support of transverse bulkheads at the ends of tanks exceeding 40 feet in length, *see* Table 64, note 2.

Plating

4604 Bulkheads may be plated horizontally or vertically and the thickness of plating is to be in accordance with Table 71 and associated notes.

Stiffening and Support

4605 Bulkheads may be stiffened by horizontal or vertical stiffeners supported as necessary by vertical webs or horizontal girders.

4606 The scantlings of horizontal or vertical stiffeners are to be derived from Table 72 and associated notes.

4607 For transverse bulkheads the scantlings of vertical webs and horizontal girders are to be derived from Table 64 and associated notes.

4608 For longitudinal bulkheads the scantlings and arrangements of the vertical webs and horizontal girders are to be generally as required for the side of the ship. (*See* D 41 and Tables 60, 63 and 64.)

4609 Stiffeners are to be bracketed or otherwise connected at their ends to provide adequate fixity and, for horizontal stiffeners, continuity of strength at the bulkheads. The end brackets of longitudinal bulkhead vertical stiffeners are to be as required by Table 76 F.

All stiffeners are to be connected to the supporting webs or girders. (*See* Table 76 E.)

4610 The plating of transverse bulkheads is to be effectively stiffened to support loads transmitted by end connections of longitudinal bulkhead, shell and deck longitudinals.

4611 Vertical webs and horizontal girders are to be attached at their ends by flanged brackets of which the length of the arms is to be equal to the depth of the web.

Corrugated Bulkheads

4612 The strength and stiffness of corrugated bulkheads are to be not less than required for flat bulkheads.

4613 Corrugations may be arranged vertically at transverse bulkheads only; they are to be of the same form at each side of horizontal girders. Vertical webs or horizontal girders are to be provided as necessary to support the bulkhead structure and to maintain the rigidity of the corrugations.

4614 Structural continuity is to be maintained at the junction of longitudinal and transverse bulkheads. All brackets or similar connections are to be arranged to minimise local stresses in the bulkhead plating either by easy tapering or by local plating reinforcement.

Section 47

STRUCTURAL ARRANGEMENTS AT FORE END

General

4701 The following requirements are applicable to tankers framed transversely forward of the forward cofferdam and having deep tanks between the cofferdam and the fore peak. If other arrangements are adopted equivalent strength is to be provided.

Frame Spacing

4702 Frames between the forward cofferdam and the fore peak bulkhead are to be spaced 27 inches apart or as required by Table 12, whichever is less.

Bottom Construction

4703 Bottom longitudinals in the forward ·2L in the centre cargo tanks are to be supported by additional intermediate transverses which may be of reduced depth but

not less than the depth of the longitudinals. Alternatively, if the bottom longitudinals are riveted (*see* Table 76 H) intermediate transverses need not be fitted.

4704 In deep tanks floors are to be fitted at every frame. The scantlings of floors are to be determined from Table 73 and associated notes.

4705 Intercostal side girders are to be fitted between the floors, in line with alternate bottom longitudinals in the forward cargo tanks, and are to be extended as far forward as practicable.

4706 The thickness of the three strakes of shell plating next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, between ·05L and ·25L from the fore end is to be determined from Table 74 and associated notes.

Side Framing

4707 The scantlings of frames in deep tanks are to be determined from Table 12 and associated notes, the depth h being measured at the mid-length of the tank from the top of floors to the tank top at side. The frames are to be attached to the floors by efficient brackets.

In tanks of unusual depth h may be measured to a suitable side stringer (*see* 4710 to 4712) provided the strength of this stringer, and of the supporting webs, is adequately increased.

If the spacing differs from that required by 4702, the modulus is to be modified in direct proportion.

4708 In the hold above the deep tank the scantlings of frames are to be determined from Table 12 and associated notes, h being measured at the mid-length of the hold from the tank top to the lowest deck at side, but the resulting modulus may be multiplied by a factor equal to 1 minus half the ratio of the depth of the tank, at mid-length, to the depth D of the ship amidships.

4709 The scantlings of frames in 'tween decks of normal height are to be determined from Table 13, col. D, and associated notes. If the 'tween deck height exceeds 10 feet the arrangements will be specially considered.

Web Frames and Side Stringers

4710 Web frames of scantlings derived from Table 75 and associated notes are to be fitted not more than four frame spaces apart and are to extend from the floors to the first flat or deck above the load water line.

4711 Side stringers are to have scantlings required by Table 75 and associated notes. Those in the deep tank are to be in line with the stringers in the fore peak, but, above the deep tank top, stringers may be fitted about 8 feet apart.

4712 Web frames are to be suitably bracketed at top and bottom, and stringers are to be bracketed to the bulkheads.

The stringer web plates and face plates are to be efficiently connected to the web frames.

Deep Tank Top

4713 The scantlings and arrangements of the deep tank top are to be as required by D 1905 to D 1908.

Fore Peak

4714 The scantlings and arrangements are to comply with D 902 to D 904.

Continuity of Strength

4715 Continuity of strength is to be maintained at the scarphing of the longitudinal and transverse framing and in cofferdams.

Cross-reference

4716 For structural details and connections, *see* D 49 and Table 76.

Section 48

STRUCTURAL ARRANGEMENTS AT AFTER END

General

4801 The following requirements are applicable when a system of transverse framing, including that of the bottom and deck, is adopted; if longitudinal framing is used equivalent strength is to be provided.

Double Bottom

4802 The scantlings and arrangements of the double bottom are to be suitable to the type and power of the machinery, but are not to be less in strength or effectiveness than required by D 5 for the midship portion of the double bottom.

Transverse Framing

4803 The scantlings of the side frames are to be determined from Table 12 and associated notes, h being measured at the fore end of the machinery space from the top of the double bottom at side to the lowest deck, flat or equivalent wide stringer.

4804 If the frames are supported at about mid-height by a stringer having the scantlings required by 4807, the modulus of the frames may be reduced by 30 per cent.

Web Frames and Side Stringers

4805 Web frames in the machinery space are to be fitted not more than five frame spaces apart, and are to have scantlings derived from Table 75 and associated notes, but h is to be measured as required by 4803. The face area, unless a stringer is fitted, may be half the area required by the Table and notes, but not less than the area of a $3\frac{1}{2}$ inch flange; if a stringer is fitted the face area of the web frame is to be the area required by the Table and notes.

4806 Above the lowest deck, or equivalent, webs are to be fitted in line with those below and are to extend to the strength deck. The depth and thickness of these webs are to be determined using a value of 12 feet for h, without corrections, but need not exceed the depth and thickness of the lower webs. The face is to be stiffened by a $3\frac{1}{2}$ inch flange, or equivalent.

4807 If it is desired to fit a stringer, the depth and thickness of the stringer web plate are to be the same as required for the web frames, but the edge may be stiffened by a $3\frac{1}{2}$ inch flange, or equivalent.

4808 Web frames are to be suitably bracketed at top and bottom and stringers are to be bracketed to the bulkheads. The stringer web plates and face plates are to be efficiently connected to the web frames.

Strong Beams and Pillars

4809 Strong beams or other efficient cross ties are to be fitted in the machinery openings at as low a level as practicable, and are to be connected to web frames. When this is impracticable, the size of the openings is to be restricted. Efficient pillaring is to be provided.

Decks

4810 Decks in the machinery space are to be constructed in accordance with D 11, D 14 and D 15, and the appropriate Tables.

Oil Fuel Bunkers

4811 The structural arrangements in the cargo tanks are to be maintained in oil fuel bunkers at the fore end of machinery spaces. The scantlings of the sides, bottom and deck are to be as required for cargo tanks, but the scantlings of the bulkheads are to comply with the requirements of D 20.

After Peak

4812 The scantlings and arrangements are to comply with D 908.

Continuity of Strength

4813 Continuity of strength is to be maintained at the scarphing of the longitudinal and transverse framing and in cofferdams.

The longitudinal deck framing is to extend to at least one-third of the breadth of the ship into the poop. The terminating positions of the longitudinal system at sides and bottom are to be staggered, and should not coincide with the position of the poop front bulkhead.

Cross-reference

4814 For structural details and connections, *see* D 49 and Table 76.

Section 49

STRUCTURAL DETAILS

Transverses and Webs, Stringers and Girders

4901 All primary supporting members, such as transverses and webs, stringers and girders, are to be so arranged that effective continuity of strength throughout their length is ensured and abrupt changes in depth or section at their connections are avoided; if the edges are flanged, the junction of the flange of the member itself with that of the bracket is to be of careful design and execution. Primary supporting members are to have adequate end fixity, web stiffening and lateral support. The following paragraphs are to be complied with or equivalent alternatives provided.

Arrangements at Ends of Primary Supporting Members

4902 When face plates are carried continuously along the edges of end brackets of primary supporting members, their butts are to be kept clear of the toes of the brackets.

If not carried along the edge of the bracket the face plates of these members are to extend a reasonable distance beyond the toes of the brackets.

4903 End brackets are to be stiffened as follows:—

Length of free edge		Bracket stiffening	
Above	Not exceeding	Flange or face plate	Additional flat stiffr.
Inches	Inches	Inches	Inches
	50	4	
50	65	5	
65	80	5	4
80	100	6	4
100		8	5

The bracket stiffener is to be parallel to the free edge and generally not more than a quarter of the throat depth from it.

4904 When a bracket is attached to a flat on bulkhead plating the flat is to be well tapered off beyond the toe of the bracket.

4905 Where members abut on both sides of bulkheads or on other members care is to be taken that they are in alignment.

4906 Where a bracket or the end of a member is attached to unsupported plating arrangements are to be made to distribute the load effectively.

Web Stiffening

4907 Stiffeners are to be fitted to web plates at each frame, longitudinal or bulkhead stiffener or as otherwise necessary.

Stiffeners are to have the following scantlings or equivalent:—

Depth of girder		Stiffeners		
Above	Not exceeding			
Inches	Inches	Inches		
	20	3	Flats	All long
20	24	3	Flats	Short & long alt.
24	36	5	Flats	Short & long alt. All long in way of end bkts.
36	48	6	Flats	All long
48	60	7	Flats	All long
60	72	6 × 3	Toe welded angles	All long
72		7 × 3	Toe welded angles	All long

The depth of stiffeners is to be not less than required for the connection given in Table 76 E.

Long stiffeners are to extend to the face edge of the web but need only be attached to the face if required by 4908.

Short stiffeners are to extend to half the depth of the web, but at least beyond the lightening holes and 6 inches beyond the notches.

Lateral Stability

4908 Tripping brackets are to be fitted at suitable intervals. In general, they should be fitted near the toes of the end brackets and where the span is long additional brackets are to be fitted as necessary.

Alternatively, web stiffeners may be so tapered as to provide a wide base capable of giving lateral stability as well as stiffening the web.

Face plates of considerable width are to be supported if necessary against tripping.

Notches

4909 All notches in primary supporting members are to have well rounded corners and smooth edges and are not to be larger than necessary. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

Lightening and Access Holes

4910 The diameter of lightening holes is not to exceed 20 per cent of the depth of the web; the holes should be placed at not less than half the depth of the web from the face and equidistant from the corners of notches for frames or stiffeners. Lightening holes are not to be cut in horizontal girders on the ship's side and longitudinal bulkheads. Access holes or foot holes may be cut in deep bottom transverses and centre girders with suitable compensation if necessary. All holes are to have smooth edges and are to be kept well clear of notches and the toes of brackets.

Drain and Air Holes

4911 Small drain or air holes may be cut in deep framing members and in longitudinals and stiffeners. These holes should be kept clear of the toes of end brackets and are to be well rounded with smooth edges.

Minimum Thicknesses

4912 No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

Welded Connections

4913 The requirements for welded connections and details of scalloped construction, are given in Table 76. All scallops are to have well rounded corners and smooth edges (for general particulars see Table 76A). Scallops are not to be cut in the connections of end brackets to shell, bulkheads or deck and such scallops in the stiffening members are to commence well clear of the toe of the bracket. Scallops in longitudinals, side frames and stiffeners are to be omitted for at least 9 inches on each side of intersection with a primary supporting member. Scallops are not to be cut in bottom transverses or in horizontal girders on ship's side or longitudinal bulkheads, and in ships over 400 feet

in length scallops are not to be cut in the lower half of side transverses or in vertical web plates to longitudinal and transverse bulkheads.

Riveted Construction

4914 In riveted construction arrangements are to be generally equivalent to the requirements of this Section and the riveting is to be as required by Table 76.

Section 50

HATCHWAYS

Oiltight Hatchways

5001 Oiltight hatchways are to be kept to the minimum size required to provide reasonable access and ventilation to each compartment. The corners of hatchways are to be well rounded and smooth.

5002 The coamings and covers are to be as required by 5004 to 5006.

5003 The arrangements at hatchways for ventilation and sounding are to be as required by Chapter E.

Coamings

5004 Coaming plates not exceeding 32 inches in height are to be ·40 inch in thickness.

Covers

5005 Where the area of the hatchway cover does not exceed 12 square feet in a circular hatchway, or 16 square feet in a rectangular hatchway, the thickness of the cover is to be ·50 inch.

If the area exceeds the above but does not exceed 25 square feet the thickness of the cover is to be ·60 inch or may be ·50 inch if stiffened by 4 inch flats spaced 24 inches apart.

5006 Covers are to be secured by fastenings spaced not more than 18 inches apart in a circular hatchway, or 15 inches apart in a rectangular hatchway and not more than 9 inches from the corners.

21st July, 1955.

Hatchways to Spaces other than Oil Compartments

5007 Hatchways are to be constructed in accordance with the requirements of D 23 except that efficient steel watertight covers are to be fitted to hatchways situated on expansion trunks and on the strength deck, either where exposed or inside open superstructures.

Hatchways situated on the forecastle deck are to have steel covers except where efficient steel watertight covers are fitted to the hatchways inside the forecastle.

Section 51

TESTING

General

5101 Each cargo tank and cofferdam is to be separately tested, either before the ship is launched or afterwards in dry dock, by filling with water to the test head.

In the case of large tankers for which complete testing on the building berth or in dry dock may be impractical, alternative arrangements, whereby the underwater shell plating may be tested on the berth and the remaining structure tested afloat, will be specially considered. In all cases the final test is to be carried out by separately filling each tank with water to the test head.

Test Head

5102 The test head for cargo tanks is to be 8 feet above the highest point of the tank, excluding hatchways; that for cofferdams is to be to the top of the hatchway.

Bunkers and Deep Tanks

5103 Bunkers and deep tanks are to be tested as required by D 1914 and D 2030 respectively.

Cross-references

5104 For pumping arrangements and ventilation of cargo tanks, *see* Chapter E.

For special surveys of petroleum tankers, *see* C 3.

SHIPS SPECIALLY DESIGNED FOR CARRYING ORE

Section 60

ORE CARRIERS

General

6001 The Class 100A1 Ore Carrier will be assigned, in accordance with the provisions of Chapter B, to sea-going ships specially designed for the carriage of ore cargoes and built in accordance with, or by standards equivalent to, the relevant rules and the provisions of this Section.

6002 The requirements of D 1 to D 34 and D 40 to D 51 apply as may be relevant to ore carriers, except as otherwise required by the following rules.

Structural Design

6003 The following rules are intended for single deck ore carriers, with machinery aft and having two longitudinal bulkheads and a system of framing as required in D 4003.

6004 A double bottom is to be fitted in way of the cargo holds.

6005 The number of watertight bulkheads in the cargo holds may be as required by D 16.

6006 When it is intended to carry liquid cargoes in the compartments adjacent to the dry cargo holds, the scantlings and arrangements are to comply with the rules relevant to such cargoes. In such cases the class notation may be suitably modified.

6007 When the compartments adjacent to the dry cargo holds are constructed in accordance with the Rules for Petroleum Tankers and petroleum is carried in these compartments at the same time as ore or other cargo is carried in the central holds, effective arrangements are to be provided to isolate the two cargoes from each other.

Draught

6008 When a draught in excess of the cargo ship draught is desired, the longitudinal bulkheads are to be not less than ·2B from the ship's sides, the spacing of the watertight bulkheads in the side tanks is not to exceed ~~·075L~~ L/24 + 20 FT, steel hatch covers are to be fitted and the provisions of D 4007 complied with.

Longitudinal Strength

6009 The scantlings of the deck outside the line of openings and those of the shell and topsides are to be such that the longitudinal strength of the ship is equivalent to the standards required for petroleum tankers.

The midship thicknesses of the deck, shell and topside plating are to extend over ·5L amidships.

Shell Plating

6010 Bottom Plating The thickness of the keel and bottom plating may be derived from D 7 and Table 14, but the thickness derived from Table 14 is to be increased at the rate of 10 per cent for each increment of ·1D in the excess height of the inner bottom over the rule height of centre girder given in Table 6. The thickness of the bottom plating need not, however, exceed the requirements of D 43.

6011 Side Shell Plating The thickness of the side shell plating is to be in accordance with the requirements of D 43.

Double Bottom Structure

6012 The scantlings and arrangements in the double bottom are generally to be governed by D 5 modified as below and as may be necessary to suit the details of construction proposed.

6013 Transverses Transverses under cargo holds are not to be spaced more than 8 feet apart. The height of the double bottom is not to be less than the rule height of the centre girder given in Table 6 increased in the ratio of twice the breadth of the ore hold to the breadth of the ship.

6014 Bottom Longitudinals The section modulus of the bottom longitudinals as derived from Table 10 is to be increased at the rate of 50 per cent for each increment of ·1D in the excess height of the double bottom over the rule height of centre girder given in Table 6, but need not exceed the requirements of D 42.

6015 Inner Bottom Longitudinals The section modulus of the inner bottom longitudinals as derived from Table 10 is to be increased in the ratio of breadth of ship to breadth of ore hold, but is to be at least 20 per cent above the requirements of D 5.

Struts should not be fitted to the longitudinals between the floors.

6016 INNER BOTTOM PLATING The thickness of the inner bottom plating is to be increased by ·20 inch above the requirements of Table 6, or alternatively a double ceiling is to be fitted.

Side and Deck Longitudinals

6017 Side and deck longitudinals are to be in accordance with the requirements of D 42.

Transverse Side Framing

6018 Transverse side frames are to be in accordance with the requirements of D 42.

Rudder

6019 The rudder may be in accordance with the requirements of D 26.

Equipment

6020 The equipment is to be in accordance with D 33 modified, if required, by D 4012.

6021 Special consideration is to be given to details of construction not specifically mentioned in the above rules.

21st April, 1955

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PETROLEUM TANKERS

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The scantlings of rolled sections are based on the British Standards as revised in 1924; alternative sections will be considered by the Committee.

BAR KEELS AND STEMS

LENGTH L	BAR KEELS	STEMS
Feet	Inches	Inches
100	6×1	5×1
125	$6\frac{1}{2} \times 1\frac{1}{4}$	$5\frac{1}{4} \times 1\frac{1}{8}$
150	$7 \times 1\frac{1}{2}$	$5\frac{1}{2} \times 1\frac{1}{4}$
175	$7\frac{1}{4} \times 1\frac{3}{4}$	$5\frac{3}{4} \times 1\frac{1}{2}$
200	$7\frac{1}{2} \times 2$	$6 \times 1\frac{5}{8}$
225	$8 \times 2\frac{1}{8}$	$6\frac{1}{2} \times 1\frac{3}{4}$
250	$8\frac{1}{4} \times 2\frac{1}{4}$	$7 \times 1\frac{7}{8}$
275	$8\frac{1}{2} \times 2\frac{3}{8}$	$7\frac{1}{2} \times 2$
300	$9 \times 2\frac{1}{2}$	$8 \times 2\frac{1}{8}$
325	$9\frac{1}{2} \times 2\frac{5}{8}$	$8\frac{1}{4} \times 2\frac{1}{4}$
350	$10 \times 2\frac{3}{4}$	$8\frac{1}{2} \times 2\frac{3}{8}$
375		$8\frac{3}{4} \times 2\frac{1}{2}$
400		$9 \times 2\frac{5}{8}$
425		$9\frac{1}{2} \times 2\frac{3}{4}$
450		$10 \times 2\frac{7}{8}$
475		$10\frac{1}{2} \times 3$
500		11×3
525		$11\frac{1}{4} \times 3$
550		$11\frac{1}{2} \times 3\frac{1}{8}$
575		$11\frac{3}{4} \times 3\frac{1}{4}$
600		$12 \times 3\frac{3}{8}$
625		$12 \times 3\frac{1}{2}$
650		$12 \times 3\frac{3}{4}$

TABLE 2 STERNFRAMES WITH APERTURES

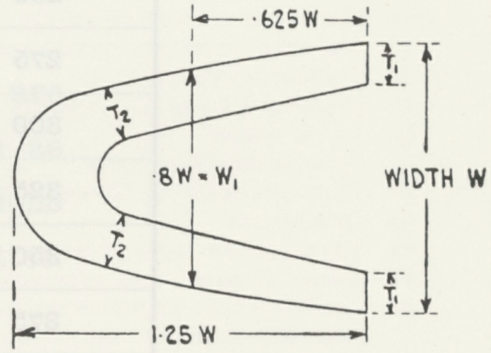
LENGTH L	WIDTH AND THICKNESS						
	SOLID		CASTINGS			BUILT	
	WIDTH		WIDTH	THICKNESS		WIDTH	THICKNESS
	Rectanguiar	Streamlined W	W	T_1	T_2	W	
1	2	3	4	5	6	7	8
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	2·5						
120	2·9						
140	3·3						
160	3·7						
180	4·1						
200	4·5	6·0	8·0	$\frac{3}{4}$	$1\frac{1}{4}$	10·0	·80
220	4·9	6·5	8·4	$\frac{7}{8}$	$1\frac{3}{8}$	10·4	·80
240	5·3	7·0	8·8	1	$1\frac{1}{2}$	10·8	·85
260	5·7	7·5	9·2	$1\frac{1}{8}$	$1\frac{5}{8}$	11·2	·85
280	6·1	8·0	9·5	$1\frac{1}{8}$	$1\frac{5}{8}$	11·6	·90
300	6·5	8·4	9·8	$1\frac{1}{4}$	$1\frac{3}{4}$	12·0	·90
320	6·9	8·8	10·1	$1\frac{1}{4}$	$1\frac{3}{4}$	12·4	·95
340	7·3	9·1	10·4	$1\frac{3}{8}$	$1\frac{7}{8}$	12·8	1·00
360	7·6	9·4	10·7	$1\frac{3}{8}$	2	13·2	1·05
380	7·9	9·7	11·0	$1\frac{1}{2}$	$2\frac{1}{8}$	13·6	1·10
400	8·2	10·0	11·3	$1\frac{1}{2}$	$2\frac{1}{4}$	14·0	1·15
420	8·5	10·2	11·6	$1\frac{5}{8}$	$2\frac{3}{8}$	14·4	1·20
440	8·7	10·4	11·9	$1\frac{5}{8}$	$2\frac{3}{8}$	14·8	1·25
460	8·9	10·6	12·1	$1\frac{3}{4}$	$2\frac{1}{2}$	15·2	1·25
480	9·1	10·8	12·3	$1\frac{3}{4}$	$2\frac{1}{2}$	15·6	1·30
500	9·3	11·0	12·5	$1\frac{3}{4}$	$2\frac{1}{2}$	16·0	1·30
520	9·5	11·2	12·7	$1\frac{7}{8}$	$2\frac{1}{2}$	16·4	1·35
540	9·7	11·4	13·0	$1\frac{7}{8}$	$2\frac{1}{2}$	16·8	1·35

NOTES.—TABLE 2

1. The dimensions given in the Table apply to both propeller post and rudder post.

2. The fore and aft dimension of the section is to be 25 per cent greater than its width as given in cols. 2, 3, 4 and 7 but is not to be less than 5 inches.

3. The width w given in cols. 3, 4 and 7 for streamlined solid, cast or built sternframes is the extreme width. The width w_1 at half the fore and aft dimension of the section is assumed to be 80 per cent of the extreme width. (See sketch.)



Where the section of sternframe adopted differs from that given above an equivalent section modulus is to be obtained.

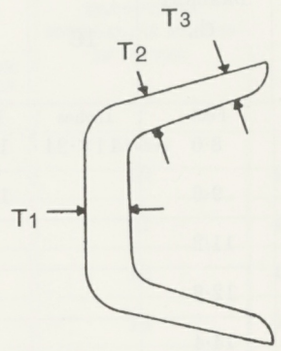
4. The sole piece in way of the aperture is to be extended in an athwartship direction to a width 50 per cent greater than that given in col. 2 ; the vertical dimension is to be equal to the width in col. 2. If a rudder post is not fitted the scantlings of the sole piece will be specially considered.

5. The boss of the propeller post is to have a finished thickness of metal round the bore equal to 60 per cent of the width given in col. 2.

6. The scantlings given in cols. 5, 6 and 8 are minima.

7. For scantlings of gudgeons *see* D 313.

LENGTH L	SOLID	CASTING		
	WIDTH	THICKNESS		
		T_1	T_2	T_3
Feet	Inches	Inches	Inches	Inches
160	1·6			
180	1·8			
200	2·0			
220	2·2	$1\frac{1}{4}$	1	$\frac{3}{4}$
240	2·4	$1\frac{1}{4}$	1	$\frac{3}{4}$
260	2·6	$1\frac{1}{4}$	1	$\frac{3}{4}$
280	2·8	$1\frac{1}{2}$	1	$\frac{3}{4}$
300	3·0	$1\frac{1}{2}$	$1\frac{1}{4}$	1
320		$1\frac{3}{4}$	$1\frac{1}{4}$	1
340		$1\frac{3}{4}$	$1\frac{1}{4}$	1
360		2	$1\frac{1}{4}$	1
380		2	$1\frac{1}{2}$	$1\frac{1}{4}$
400		$2\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$
420		$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$
440		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{4}$
460		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{2}$
480		$2\frac{3}{4}$	2	$1\frac{1}{2}$
500		$2\frac{3}{4}$	2	$1\frac{1}{2}$
520		3	2	$1\frac{1}{2}$
540		$3\frac{1}{4}$	2	$1\frac{1}{2}$
560		$3\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$
580		$3\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$
600		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
620		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
640		4	$2\frac{3}{4}$	$1\frac{3}{4}$



NOTES.—TABLE 3

1. Fore and aft dimensions of solid sternposts are to be three times the width.

2. The side flanges of cast steel sternposts are to have dimensions sufficient to take the shell connection.

TABLE 4 FLOORS IN SINGLE BOTTOMS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	BREADTH B FEET									REVERSED FRAMES
			16	20	24	28	32	36	40	44	48	
Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
10	21	8·0	11×·24	12×·26	13×·26	15×·28	16×·30					3 × 2½×·30
12	21½	9·6		13×·26	14×·26	16×·28	18×·30					3 × 3 × ·34
14	22	11·2			15×·28	17×·30	19×·32	21×·34				3½×3 × ·38
16	22½	12·8				18×·30	20×·32	22×·34	24×·36			4 × 3 × ·40
18	23	14·4					21×·34	23×·36	25×·38	27×·40		5 × 3 × ·44
20	23½	16·0						24×·36	26×·38	28×·40	30×·42	5 × 3 × ·48
22	24	17·6							27×·38	29×·40	31×·42	6 × 3 × ·50
24	25	19·2							28×·40	30×·40	32×·42	6 × 3 × ·56

NOTES.—TABLE 4

1. **Corrections.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b depth of floors is to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of half an inch per foot of difference.

FOR FRAME SPACING.

If the spacing amidships is $\frac{\text{greater}}{\text{less}}$ than that given in the Table the thickness of the floors and of the reversed frames is to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of ·01 inch and ·02 inch respectively for every two inches of difference.

2. **Increases in machinery spaces.**—In the engine room the floors are to be increased ·04 inch and in the boiler room the floors and the reversed frames are to be increased ·10 inch beyond the thicknesses given in the Table.

KEELSONS IN SINGLE BOTTOMS — TABLE 5

LENGTH L	CENTRE KEELSONS						SIDE KEELSONS	
	PLATE KEEL ANGLES		DOUBLE TOP ANGLES	THICKNESS OF VERTICAL PLATES AND FOUNDATION PLATES IF FITTED		BREADTH OF FOUNDATION PLATES IF FITTED	SINGLE TOP ANGLE	THICKNESS OF INTERCOSTAL PLATE
	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS	THROUGHOUT	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS			
1	2	3	4	5	6	7	8	9
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	3 × 3 × ·26	·26	3 × 3 × ·26	·30	·26	10	4 × 3 × ·28	·24
140	3 × 3 × ·32	·30	3½ × 3 × ·30	·34	·28	11	4 × 3 × ·30	·26
180	3 × 3 × ·36	·34	4 × 3 × ·32	·38	·32	12	4 × 3 × ·34	·30
220	3½ × 3½ × ·40	·38	5 × 3 × ·32	·40	·34	14	5 × 3 × ·34	·32
260	3½ × 3½ × ·42	·40	5 × 3 × ·38	·42	·36	16	5 × 3 × ·36	·36
300	3½ × 3½ × ·44	·42	6 × 3½ × ·40	·46	·38	18	5 × 3 × ·40	·38

KEELSONS IN TUGS

LENGTH L	CENTRE KEELSON ON TOP OF FLOORS WITH BAR KEEL		SIDE KEELSON ON TOP OF FLOORS
	SINGLE CHANNEL	DOUBLE BULB ANGLES	SINGLE ANGLE
Feet	Inches	Inches	Inches
100	8 × 3½ × 3½ × ·40	5 × 3 × ·38	5 × 4 × ·36
120	9 × 3½ × 3½ × ·44	5 × 3 × ·46	5 × 4 × ·38
140	10 × 3½ × 3½ × ·48	6 × 3 × ·42	5 × 4 × ·40
160	12 × 3½ × 3½ × ·48	6 × 3 × ·48	5 × 4 × ·44

NOTES.—TABLE 5

In boiler rooms the thickness of the centre and side keelsons, foundation plates and angles not covered by cement is to be increased by ·10 inch.

TABLE 6 DOUBLE BOTTOMS

LENGTH L	FRAME SPACING AMIDSHIPS	CENTRE GIRDER					MARGIN PLATE		FLOOR PLATES, GIRDERS AND BRACKETS INSIDE TANK		
				THICKNESS			THICKNESS		THICKNESS		
		BASIC DRAUGHT d_b	HEIGHT ABOVE BASE LINE	FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS	IN BOILER ROOM	IN HOLDS AND ENGINE ROOM	IN BOILER ROOM	FLOORS IN HOLDS AND ENGINE ROOM. SIDE GIRDERS IN ENGINE ROOM	FLOORS AND SIDE GIRDERS IN BOILER ROOM	SIDE GIRDERS IN HOLDS
1	2	3	4	5	6	7	8	9	10	11	12
Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
140	22	8·4	26	·32	·26	·42	·28	·38	·26	·36	·26
160	22½	9·6	26	·35	·29	·45	·31	·41	·27	·37	·26
180	23	10·8	27	·37	·31	·47	·33	·43	·28	·38	·27
200	23½	12·0	28	·39	·33	·49	·35	·45	·29	·39	·27
220	24	13·2	29	·40	·34	·50	·37	·47	·30	·40	·28
240	24½	14·4	30	·41	·35	·51	·39	·49	·31	·41	·29
260	25	15·6	31	·42	·36	·52	·40	·50	·32	·42	·30
280	25½	16·8	32	·44	·37	·54	·41	·51	·33	·43	·31
300	26	18·0	34	·45	·38	·55	·42	·52	·34	·44	·32
320	26½	19·2	35	·46	·39	·56	·43	·53	·35	·45	·33
340	27	20·4	37	·48	·40	·57	·44	·54	·36	·46	·34
360	27½	21·6	38	·49	·41	·58	·46	·55	·37	·47	·34
380	28	22·8	40	·50	·42	·59	·47	·56	·38	·48	·35
400	28½	24·0	42	·51	·43	·60	·49	·57	·39	·49	·36
420	29	25·2	43	·52	·44	·61	·50	·58	·40	·50	·36
440	29½	26·4	45	·53	·45	·62	·52	·59	·41	·51	·37
460	30	27·6	46	·54	·46	·62	·53	·60	·42	·52	·38
480	30½	28·8	48	·55	·47	·63	·55	·62	·43	·53	·39
500	31	30·0	49	·56	·48	·64	·56	·63	·44	·54	·40
520	31½	30·0	49	·57	·49	·65	·58	·65	·45	·55	·41
540	32	30·0	50	·58	·50	·66	·60	·66	·46	·55	·42
560	32½	30·0	51	·59	·51	·66	·62	·68	·47	·56	·43
580	33	30·0	51	·60	·52	·67	·64	·69	·48	·56	·44
600	33½	30·0	52	·61	·53	·67	·66	·71	·49	·57	·44
620	34	30·0	52	·62	·54	·68	·67	·72	·50	·57	·45
640	34½	30·0	53	·63	·55	·68	·69	·74	·51	·58	·46

NOTES.—TABLE 6

1. **Corrections.**

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b the height of the centre girder to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of half an inch for each foot of difference.

FOR FRAME SPACING.

If the spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in col. 2 the thickness of the floor and bracket plates, margin plate and inner bottom plating to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of ·01 inch for every two inches of difference.

The thickness of the inner bottom plating in the engine and boiler rooms and of the middle line strake throughout should not be corrected for frame spacing but is not to be less than the thickness derived from col. 16 after correction.

The thickness of watertight floors is to be ·08 inch greater than the thickness given in col. 10, but need not exceed ·54 inch.

INNER BOTTOM PLATING							ANGLE CONNECTIONS					LENGTH
MIDDLE LINE STRAKE EXCEPT IN BOILER ROOM			REMAINDER				ANGLES CONNECTING CENTRE GIRDER TO FLAT PLATE KEEL		ANGLES CONNECTING CENTRE GIRDER TO INNER BOTTOM		ANGLES CONNECTING MARGIN PLATE TO SHELL PLATING	L
BREADTH	THICKNESS											
	FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS	IN HOLDS		IN ENGINE ROOM	IN BOILER ROOM INCLUDING MIDDLE LINE STRAKE	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS		
			FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS								
13	14	15	16	17	18	19	20	21	22	23	24	25
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Feet
38	·28	·26	·26	·26	·30	·42	3 × 3 × ·32	·30	$2\frac{1}{2}\times2\frac{1}{2}\times$·28	·28	3 × 3 × ·30	140
39	·30	·28	·28	·27	·32	·44	3 × 3 × ·34	·32	$2\frac{1}{2}\times2\frac{1}{2}\times$·29	·29	3 × 3 × ·32	160
40	·32	·30	·30	·28	·34	·45	3 × 3 × ·36	·34	3 × 3 × ·30	·30	3 × 3 × ·34	180
41	·34	·31	·31	·29	·36	·47	3 × 3 × ·38	·36	3 × 3 × ·32	·31	3 × 3 × ·36	200
42	·36	·32	·32	·30	·38	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·40	·38	3 × 3 × ·34	·32	3 × 3 × ·38	220
43	·38	·33	·33	·31	·39	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·41	·39	3 × 3 × ·36	·34	3 × 3 × ·40	240
44	·40	·34	·34	·32	·40	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·42	·40	3 × 3 × ·38	·36	3 × 3 × ·42	260
45	·41	·35	·35	·32	·41	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·43	·41	3 × 3 × ·39	·37	3 × 3 × ·44	280
46	·42	·36	·36	·33	·42	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	·42	3 × 3 × ·40	·38	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	300
47	·44	·37	·37	·33	·44	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·43	3 × 3 × ·41	·39	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	320
48	·45	·38	·38	·34	·45	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·44	3 × 3 × ·42	·40	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	340
49	·47	·39	·39	·35	·47	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·45	3 × 3 × ·43	·41	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	360
50	·48	·40	·40	·36	·48	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·46	3 × 3 × ·44	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	380
51	·49	·41	·41	·37	·49	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	400
52	·50	·42	·42	·38	·50	·57	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	420
53	·51	·43	·43	·39	·51	·57	5 × 5 × ·52	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·43	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	440
54	·52	·44	·44	·40	·52	·58	5 × 5 × ·54	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·44	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	460
55	·54	·46	·46	·42	·54	·59	5 × 5 × ·55	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·45	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	480
56	·55	·47	·47	·43	·55	·60	5 × 5 × ·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·46	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	500
57	·57	·49	·49	·45	·57	·61	5 × 5 × ·58	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	520
58	·58	·50	·50	·46	·58	·62	5 × 5 × ·60	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	540
59	·60	·52	·51	·47	·60	·63	5 × 5 × ·61	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	560
60	·61	·53	·52	·48	·61	·64	5 × 5 × ·62	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	580
61	·63	·55	·53	·49	·63	·65	5 × 5 × ·64	·58	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	600
62	·64	·56	·54	·50	·64	·66	5 × 5 × ·66	·60	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	620
63	·66	·58	·55	·51	·66	·67	5 × 5 × ·68	·62	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	640

NOTES.—TABLE 6 (*concluded*)

2. **Depth of margin plate** is not to be less than 80 per cent of the depth of centre girder corrected by note 1, where the length of the ship does not exceed 350 feet or 85 per cent where the length is 400 feet and above, with intermediate values in proportion. At the after end the depth may be reduced to 85 per cent of the depth amidships.

3. **Thickness of connecting angles not given in Table.**—The thickness of the vertical angles connecting intercostal girders to floors is not to be less than that of the intercostal plate. The thickness of the frames, reversed frames and other connecting angles is not to be less than the thickness of the floors.

4. **Width of faying flanges.**—For width of faying flanges for all angles, unless specified in the Table, *see* D 3202.

5. **In boiler rooms** angles not covered by cement are to be increased by ·10 inch in thickness.

6. **Oil fuel.**—For thickness of inner bottom plating when oil fuel is carried in the double bottom, *see* D 2020.

TABLE 7 BRACKET FLOORS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN* d *and* d_b	UNSUPPORTED SPAN FEET						
				3	4	5	6	7	8	
Feet	Inches	Feet	Per cent	INCHES *Modulus—Inches*^{3}						
12	21½	9·6	*10·4*	3½×2½×·36 *1·55*	4 × 3 × ·47 *2·60*	5 × 3 × ·40 *3·30*				ANGLES
14	22	11·2	*9·0*	4 × 3 × ·34 *1·90*	5 × 3 × ·38 *3·15*	6 × 3 × ·33 *4·00*				
16	22½	12·8	*7·8*	4 × 3 × ·40 *2·20*	5 × 3 × ·44 *3·65*	5 × 3 × ·35 *4·65*	5 × 3 × ·40 *5·15*			
18	23	14·4	*7·0*	4 × 3 × ·46 *2·50*	6 × 3 × ·35 *4·20*	5 × 3 × ·42 *5·35*	5½×3 × ·37 *5·95*	6 × 3 × ·34 *6·80*	6 × 3 × ·46 *8·45*	
20	23½	16·0	*6·2*	5 × 3 × ·34 *2·85*	5 × 3 × ·36 *4·75*	5½×3 × ·38 *6·05*	6 × 3 × ·34 *6·80*	6 × 3 × ·40 *7·65*	7 × 3 × ·34 *9·60*	
22	24	17·6	*5·7*	5 × 3 × ·39 *3·25*	5 × 3 × ·42 *5·35*	6 × 3½×·34 *6·85*	6 × 3½×·39 *7·55*	6 × 3½×·48 *8·80*	7 × 3½×·41 *10·80*	
24	25	19·2	*5·2*	5 × 3 × ·44 *3·65*	5½×3 × ·39 *6·15*	6 × 3½×·40 *7·65*	6 × 3½×·46 *8·50*	7 × 3½×·35 *9·80*	7 × 3½×·49 *12·25*	
26	26	20·8	*4·8*	6 × 3 × ·35 *4·20*	6 × 3 × ·34 *6·80*	6 × 3½×·47 *8·65*	7 × 3½×·34 *9·65*	7 × 3½×·43 *11·15*	8 × 3½×·38 *13·85*	
28	27	22·4	*4·5*	5 × 3 × ·35 *4·65*	6 × 3 × ·40 *7·65*	7 × 3½×·34 *9·65*	7 × 3½×·41 *10·80*	7 × 3½×·50 *12·45*	8 × 3½×·44 *15·25*	BULB ANGLES
30	28	24·0	*4·2*	5 × 3 × ·40 *5·15*	6 × 3 × ·46 *8·45*	7 × 3½×·41 *10·80*	7 × 3½×·48 *12·05*	8 × 3½×·38 *13·85*	8 × 3½×·52 *17·15*	
32	29	25·6	*3·9*	5½×3 × ·35 *5·70*	*9·40*	7 × 3½×·47 *11·90*	8 × 3½×·35 *13·25*	8 × 3½×·44 *15·25*	9 × 3½×·40 *18·90*	
34	30	27·2	*3·7*	5½×3 × ·40 *6·25*	7 × 3 × ·38 *10·25*	*13·10*	8 × 3½×·41 *14·60*	8 × 3½×·50 *16·70*	9 × 3½×·47 *20·80*	
36	31	28·8	*3·5*	6 × 3½×·34 *6·85*	7 × 3½×·44 *11·30*	8 × 3½×·40 *14·35*	8 × 3½×·47 *16·00*	*18·30*	9 × 3½×·54 *22·70*	
38	32	30·0	*3·3*	6 × 3½×·38 *7·40*	7 × 3½×·49 *12·25*	8 × 3½×·45 *15·50*	8 × 3½×·54 *17·60*	9 × 3½×·43 *19·65*	*24·40*	
40	33	30·0	*3·3*	6 × 3½×·40 *7·65*	7 × 3½×·51 *12·65*	8 × 3½×·47 *16·00*	*18·15*	9 × 3½×·45 *20·20*	10 × 3½×·43 *25·15*	
42	34	30·0	*3·3*	6 × 3½×·42 *7·95*	*12·95*	8 × 3½×·49 *16·45*	9 × 3½×·39 *18·65*	9 × 3½×·48 *21·05*	10 × 3½×·46 *26·10*	
44	35	30·0	*3·3*	6 × 3½×·44 *8·20*	8 × 3½×·35 *13·25*	8 × 3½×·51 *16·95*	9 × 3½×·42 *19·40*	9 × 3½×·50 *21·60*	10 × 3½×·48 *26·80*	
46	36	30·0	*3·3*	6 × 3½×·46 *8·50*	8 × 3½×·37 *13·65*	8 × 3½×·53 *17·40*	9 × 3½×·44 *19·90*	9 × 3½×·52 *22·20*	10 × 3½×·50 *27·40*	
48	37	30·0	*3·3*	6 × 3½×·47 *8·65*	8 × 3½×·39 *14·10*	8 × 3½×·55 *17·85*	9 × 3½×·46 *20·50*	9 × 3½×·54 *22·70*	10 × 3½×·52 *28·10*	
50	38	30·0	*3·3*	6 × 3½×·49 *8·95*	8 × 3½×·41 *14·60*	*18·35*	9 × 3½×·48 *21·05*	9 × 3½×·56 *23·30*	10 × 3½×·54 *28·80*	

Section moduli above are given to nearest ·05

NOTES.—TABLE 7

1. **Scantlings.**—The bottom frames are to have scantlings determined from the Table; the modulus of the reversed frames may be 85 per cent of that of the bottom frames corrected as required below. For width of faying flanges *see* D 3202.

2. **Correction to modulus of frames.**

FOR DRAUGHT

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** frames, reversed frames, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in Table 56.

DETAILS OF BRACKET FLOORS — TABLE 8

DEPTH OF FRAME		RIVETS IN BRACKETS		RIVETS IN EACH END OF VERTICAL BAR ON INTERCOSTAL GIRDER		VERTICAL STRUTS BETWEEN INTERCOSTAL GIRDER AND CENTRE LINE OR MARGIN PLATE		RIVETS IN EACH END OF VERTICAL STRUTS	
		NUMBER	DIAMETER	NUMBER	DIAMETER			NUMBER	DIAMETER
1		2	3	4	5		6	7	8
Inches			Inches		Inches		Inches		Inches
$3\frac{1}{2}$ and 4	ANGLES	4	$\frac{5}{8}$	2	$\frac{5}{8}$	ANGLES	6 × 3 × ·34	2	$\frac{5}{8}$
5		5	$\frac{5}{8}$	2	$\frac{5}{8}$		6 × 3 × ·36	3	$\frac{5}{8}$
6		5	$\frac{3}{4}$	2	$\frac{3}{4}$	CHANNELS	7 × 3 × 3 × ·36	4	$\frac{3}{4}$
5 and $5\frac{1}{2}$	BULB ANGLES	5	$\frac{3}{4}$	2	$\frac{3}{4}$		8 × 3 × 3 × ·36	4	$\frac{3}{4}$
6		6	$\frac{3}{4}$	2	$\frac{3}{4}$		8 × 3 × 3 × ·40	4	$\frac{7}{8}$
7		7	$\frac{3}{4}$	3	$\frac{3}{4}$		8 × 3 × 3 × ·40	4	$\frac{7}{8}$
8		8	$\frac{3}{4}$	4	$\frac{3}{4}$		9 × 3 × 3 × ·44	5	$\frac{7}{8}$
9		8	$\frac{7}{8}$	4	$\frac{7}{8}$		10 × 3 × 3 × ·44	6	$\frac{7}{8}$
10 and above		9	$\frac{7}{8}$	4	$\frac{7}{8}$		10 × 3 × 3 × ·50	6	$\frac{7}{8}$

NOTES.—TABLE 8

1. **In boiler rooms** struts are to be increased by ·10 inch in thickness.

2. For scantlings of welded vertical struts *see* D 515.

TABLE 9 STIFFENERS TO WATERTIGHT FLOORS

Spaced 30 inches apart

DEPTH OF CENTRE GIRDER	HEIGHT OF OVERFLOW ABOVE INNER BOTTOM FEET						
	20	25	30	35	40	45	50
Inches	INCHES *Modulus—Inches*^{3}						
36	$3\frac{1}{2} \times 3 \times \cdot32$ *1·40*	$3\frac{1}{2} \times 3 \times \cdot40$ *1·75*	$4 \times 3 \times \cdot36$ *2·00*	$4 \times 3 \times \cdot43$ *2·35*	$4 \times 3 \times \cdot47$ *2·60*	$5 \times 3 \times \cdot36$ *3·00*	$5 \times 3 \times \cdot40$ *3·30*
42	$4 \times 3 \times \cdot34$ *1·90*	$4 \times 3 \times \cdot42$ *2·30*	$5 \times 3 \times \cdot32$ *2·70*	$5 \times 3 \times \cdot38$ *3·15*	$5 \times 3 \times \cdot44$ *3·65*	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot38$ *4·55*
48	$4 \times 3 \times \cdot47$ *2·60*	$5 \times 3 \times \cdot38$ *3·15*	$5 \times 3 \times \cdot44$ *3·65*	$6 \times 3 \times \cdot36$ *4·30*	$6 \times 3 \times \cdot40$ *4·75*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$5\frac{1}{2} \times 3 \times \cdot40$ *6·25*
54	$5 \times 3 \times \cdot40$ *3·30*	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot40$ *4·75*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$5\frac{1}{2} \times 3 \times \cdot40$ *6·25*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot40$ *7·65*
60	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot42$ *5·00*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot40$ *7·65*	$6 \times 3 \times \cdot46$ *8·45*	$6 \times 3 \times \cdot52$ *9·30*
66	$6 \times 3 \times \cdot42$ *5·00*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot46$ *8·45*	$6 \times 3 \times \cdot52$ *9·30*	$7 \times 3 \times \cdot40$ *10·60*	$7 \times 3 \times \cdot46$ *11·65*
72	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot46$ *8·45*	$7 \times 3 \times \cdot36$ *9·95*	$7 \times 3 \times \cdot42$ *10·95*	$7 \times 3 \times \cdot49$ *12·25*	$8 \times 3 \times \cdot38$ *13·85*

ANGLES — BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 9

1. **In boiler rooms** stiffeners are to be increased by ·10 inch in thickness.

2. Particulars of sections and moduli are given in Table 56.

LENGTH L	SPACING OF LONGITUDINALS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN d and d_b		UNSUPPORTED SPAN FEET 4	5	6	7	8	
Feet	Inches	Feet	Per cent		INCHES *Modulus—Inches*					
160	27½	9·6	*10·4*	ANGLES	5 × 3 × ·41 *3·40*	6 × 3 × ·35 *4·20*	5 × 3 × ·39 *5·05*	5½ × 3 × ·36 *5·80*	6 × 3 × ·33 *6·65*	BULB ANGLES
180	28	10·8	*9·2*		6 × 3 × ·33 *4·00*	5 × 3 × ·37 *4·85*	5½ × 3 × ·37 *5·90*	6 × 3 × ·34 *6·80*	6 × 3 × ·40 *7·65*	
200	28½	12·0	*8·3*		5 × 3 × ·34 *4·55*	5½ × 3 × ·34 *5·60*	6 × 3 × ·33 *6·65*	6 × 3 × ·40 *7·65*	6 × 3 × ·48 *8·75*	
220	29	13·2	*7·6*		5 × 3 × ·41 *5·25*	5½ × 3 × ·41 *6·40*	6 × 3 × ·39 *7·50*	6 × 3 × ·48 *8·75*	7 × 3 × ·36 *9·95*	
240	29½	14·4	*6·9*		5½ × 3 × ·37 *5·95*	6 × 3 × ·37 *7·25*	6 × 3 × ·46 *8·45*	7 × 3 × ·35 *9·80*	7 × 3 × ·43 *11·15*	
260	30	15·6	*6·4*		6 × 3 × ·33 *6·65*	6 × 3 × ·43 *8·05*	6 × 3 × ·53 *9·45*	7 × 3 × ·42 *10·95*	7 × 3 × ·50 *12·40*	
280	30½	16·8	*6·0*		6 × 3 × ·38 *7·35*	6 × 3 × ·50 *9·00*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·57 *13·70*	
300	31	18·0	*5·6*		6 × 3½ × ·44 *8·20*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·45 *11·50*	8 × 3½ × ·35 *13·25*	8 × 3½ × ·43 *15·05*	
320	31½	19·2	*5·2*		6 × 3½ × ·50 *9·05*	7 × 3½ × ·42 *10·95*	7 × 3½ × ·51 *12·65*	8 × 3½ × ·41 *14·60*	8 × 3½ × ·49 *16·45*	
340	32	20·4	*4·9*		7 × 3½ × ·37 *10·10*	7 × 3½ × ·48 *12·05*	8 × 3½ × ·38 *13·85*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·55 *17·85*	
360	32½	21·6	*4·6*		7 × 3½ × ·43 *11·15*	*13·00*	8 × 3½ × ·44 *15·25*	8 × 3½ × ·52 *17·15*	9 × 3½ × ·42 *19·40*	
380	33	22·8	*4·4*		7 × 3½ × ·48 *12·05*	8 × 3½ × ·40 *14·35*	8 × 3½ × ·49 *16·45*	*18·70*	9 × 3½ × ·48 *21·05*	
400	33½	24·0	*4·2*		*13·20*	8 × 3½ × ·45 *15·50*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·54 *22·70*	
420	34	25·2	*4·0*		8 × 3½ × ·40 *14·35*	8 × 3½ × ·50 *16·70*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	*24·45*	
440	34½	26·4	*3·8*		8 × 3½ × ·46 *15·75*	8 × 3½ × ·56 *18·05*	9 × 3½ × ·47 *20·80*	9 × 3½ × ·57 *23·60*	10 × 3½ × ·46 *26·10*	
460	35	27·6	*3·6*		8 × 3½ × ·51 *16·95*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·52 *28·10*	
480	35½	28·8	*3·4*		*18·50*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·58 *30·10*	
500	36	30·0	*3·3*		9 × 3½ × ·44 *19·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·54 *28·80*	*32·00*	

Section moduli above are given to nearest ·05

NOTES.—TABLE 10

1. **Scantlings.**—The bottom longitudinals are to have scantlings determined from the Table ; the modulus of the inner bottom longitudinals may be 85 per cent of that of the bottom longitudinals corrected as required below. For width of faying flanges *see* D 3202.

2. **Corrections to modulus of bottom longitudinals.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR SPACING OF LONGITUDINALS.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** longitudinals, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in Table 56.

TABLE 11

(SEE CONTINUATION)

ATTACHMENT OF TANK SIDE BRACKETS

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			4 INCH ORDINARY ANGLE				5 INCH ORDINARY ANGLE				6 INCH ORDINARY ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION
Feet	Inches	Inches	Inches				Inches				Inches			
10	21	28	·26	5†	—	5†								
12	21½	32	·27	5†	—	5†	·28	5†	—	5†	·29	5*	—	5†
14	22	36	·28	5†	—	5†	·29	5*	—	5†	·30	5*	—	5†
16	22½	40	·28	5*	—	5†	·29	5*	—	5*	·31	5*	—	5*
18	23	44									·32	6*	—	5*
20	23½	48									·33	6*	—	5*
22	24	52												
24	25	55												
26	26	58												
28	27	61												
30	28	64												
32	29	67												
34	30	70												
36	31	72												
38	32	74												
40	33	76												
42	34	78												
44	35	79												
46	36	81												
48	37	83												
50	38	84												

† Rivets $\frac{5}{8}$ inch diameter * Rivets $\frac{3}{4}$ inch diameter Remainder $\frac{7}{8}$ inch diameter

For notes see pages 90 & 91

TABLE 11
(SEE CONTINUATION)

FRAME															DEPTH D
6 INCH BULB ANGLE				7 INCH BULB ANGLE				8 INCH BULB ANGLE				9 INCH BULB ANGLE			
THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION	
Inches				Inches				Inches				Inches				Feet
																10
																12
·31	6*	—	5*													14
·32	6*	—	6*													16
·32	6*	—	6*	·33	6*	—	6*	·34	6*	1*	6*					18
·34	6*	—	6*	·34	6*	1*	6*	·34	6*	2*	7*					20
·35	6*	1*	6*	·35	6*	2*	6*	·35	5	1	5	·36	6	2	7	22
·36	6*	1*	6*	·36	6*	2*	6*	·36	5	2	6	·38	6	3	7	24
·38	6*	2*	6*	·38	5	1	5	·38	5	2	6	·40	6	4	8	26
				·40	5	2	5	·40	6	2	6	·41	7	4	8	28
				·41	6	2	6	·41	6	3	7	·42	7	4	8	30
								·42	7	3	7	·43	7	4	8	32
								·43	7	3	7	·44	8	4	8	34
								·44	7	4	8	·44	8	5	8	36
												·45	8	6	8	38
												·46	8	6	9	40
												·47	8	7	9	42
												·47	8	7	9	44
																46
																48
																50

† Rivets $\frac{5}{8}$ inch diameter * Rivets $\frac{3}{4}$ inch diameter Remainder $\frac{7}{8}$ inch diameter

For notes see pages 90 & 91

TABLE 11
(CONCLUDED)

ATTACHMENT OF TANK SIDE BRACKET

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			10 INCH BULB ANGLE				11 INCH BULB ANGLE				12 INCH BULB ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTI
Feet	Inches	Inches	Inches				Inches				Inches			
10	21	28												
12	21½	32												
14	22	36												
16	22½	40												
18	23	44												
20	23½	48												
22	24	52	·38	6	4	8								
24	25	55	·40	6	5	8								
26	26	58	·41	7	6	8	·42	7	6	8				
28	27	61	·42	7	6	8	·43	7	7	8	·43	8	8	9
30	28	64	·43	8	6	9	·44	8	7	9	·44	9	8	10
32	29	67	·44	8	6	9	·44	8	7	9	·45	9	8	10
34	30	70	·45	8	6	9	·45	8	7	9	·46	9	8	10
36	31	72	·45	8	6	9	·46	9	7	10	·47	9	8	10
38	32	74	·46	8	7	9	·47	9	7	10	·48	9	8	10
40	33	76	·47	8	7	10	·47	9	8	11	·48	9	9	11
42	34	78	·48	8	8	10	·48	9	9	11	·49	10	9	11
44	35	79	·48	9	8	10	·48	9	9	11	·49	10	9	12
46	36	81	·48	9	8	10	·49	9	9	11	·50	10	9	12
48	37	83	·49	9	8	10	·50	10	9	11	·50	11	9	12
50	38	84					·50	10	9	11	·50	11	9	12

Rivets $\frac{7}{8}$ inch diameter

NOTES.—TABLE 11

1. **Corrections.**—If the frame spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table, the thickness of the tank side brackets is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of ·01 inch for every two inches of difference.

2. The height of tank side brackets is to be measured at the inner edge of the frame.

TABLE 11
(CONCLUDED)

FRAME												DEPTH D
13½ INCH BULB ANGLE				15 INCH CHANNEL				17 INCH CHANNEL				
THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION	
Inches				Inches				Inches				Feet
												10
												12
												14
												16
												18
												20
												22
												24
												26
·44	9	8	10	·45	9	9	12	·46	10	9	14	28
·45	10	8	10	·46	10	9	12	·47	11	9	14	30
·46	10	8	11	·46	10	9	12	·47	11	9	14	32
·47	10	8	11	·47	10	9	12	·48	11	10	14	34
·48	10	8	11	·48	10	9	12	·49	11	10	14	36
·49	10	8	11	·49	11	9	12	·50	11	10	14	38
·50	10	9	11	·50	11	10	12	·51	12	11	15	40
·51	11	9	12	·51	11	10	13	·52	12	11	15	42
·51	11	9	12	·52	12	10	13	·52	12	11	15	44
·51	11	9	12	·52	12	10	13	·52	13	11	15	46
·52	12	10	12	·52	13	11	13	·52	14	12	15	48
·52	12	10	12	·52	13	11	13	·52	14	12	15	50

Rivets $\frac{7}{8}$ inch diameter

NOTES.—TABLE 11 (*continued*)

3. The angles connecting the tank side brackets to the margin plate are to have the same thickness as the brackets.

4. **In boiler rooms,** the tank side brackets, gussets and connecting angles are to be increased by ·10 inch in thickness.

5. For increases in way of panting region *see* D 906.

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b		FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET: 8	10	12	13	14	15	16	17	18
Feet	Inches	Feet		INCHES *Modulus—Inches*³	Per cent	← INCHES *Modulus—Inches*³ →								
10	21	8·0	ANGLES	3½×2½×·35 *1·50*	*15·0*	3½×3×·29 *1·25*	3½×3×·35 *1·50*	3½×3×·42 *1·80*	4 × 3×·36 *2·00*	4 × 3 × ·40 *2·20*				
11	21¼	8·8	ANGLES	3½×2½×·41 *1·75*	*14·0*	3½×3×·32 *1·40*	3½×3×·40 *1·75*	4 × 3×·40 *2·20*	4 × 3×·45 *2·45*	5 × 3 × ·32 *2·70*	5 × 3 × ·36 *3·00*			
12	21½	9·6	ANGLES	4 × 3 × ·36 *2·00*	*13·0*	3½×3×·37 *1·60*	4 × 3×·37 *2·05*	5 × 3×·31 *2·60*	5 × 3×·35 *2·95*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 *3·65*	6 × 3 × ·33 *4·00*		
13	21¾	10·4	ANGLES	4 × 3 × ·39 *2·70*	*12·0*		4 × 3×·44 *2·40*	5 × 3×·36 *3·00*	5 × 3×·41 *3·40*	5 × 3 × ·46 *3·80*	6 × 3 × ·35 *4·20*	6 × 3 × ·39 *4·65*	6 × 3 × ·44 *5·20*	
14	22	11·2	ANGLES	5 × 3 × ·41 *3·40*	*11·0*		5 × 3×·34 *2·85*	5 × 3×·43 *3·55*	6 × 3×·33 *4·00*	6 × 3 × ·37 *4·40*	6 × 3 × ·41 *4·85*	6 × 3 × ·46 *5·40*	6 × 3 × ·51 *6·00*	5½×3 × ·42 *6·50*
15	22¼	12·0	ANGLES	5 × 3 × ·43 *3·60*	*10·5*		5 × 3×·40 *3·30*	6 × 3×·34 *4·10*	6 × 3×·38 *4·55*	6 × 3 × ·43 *5·10*	6 × 3 × ·48 *5·65*	5½×3 × ·39 *6·15*	6 × 3 × ·34 *6·80*	6 × 3 × ·38 *7·35*
16	22½	12·8	ANGLES	5 × 3 × ·46 *3·80*	*10·0*			6 × 3×·44 *5·20*	6 × 3 × ·49 *5·75*	5½×3 × ·40 *6·25*	6 × 3 × ·35 *6·95*	6 × 3 × ·39 *7·50*	6 × 3 × ·44 *8·20*	
17	22¾	13·6	ANGLES	6 × 3 × ·34 *4·10*	*9·5*				6 × 3 × ·32 *6·50*	6 × 3 × ·36 *7·10*	6 × 3 × ·41 *7·80*	6 × 3 × ·46 *8·45*	6 × 3 × ·51 *9·15*	
18	23	14·4	ANGLES	6 × 3 × ·36 *4·30*	*9·0*	6 × 3×·50 *5·85*	5½×3×·38 *6·05*	5½×3×·42 *6·50*	6 × 3×·35 *6·95*	6 × 3 × ·39 *7·50*	6 × 3 × ·43 *8·05*	6 × 3 × ·48 *8·75*	7 × 3 × ·33 *9·45*	7 × 3 × ·39 *10·45*
19	23¼	15·2	ANGLES	6 × 3 × ·40 *4·75*	*8·5*	5½×3×·40 *6·25*	5½×3×·43 *6·60*	6 × 3×·38 *7·35*	6 × 3×·41 *7·80*	6 × 3 × ·46 *8·45*	6 × 3 × ·51 *9·15*	7 × 3 × ·36 *9·95*	7 × 3 × ·41 *10·80*	7 × 3 × ·47 *11·85*
20	23½	16·0	ANGLES	6 × 3 × ·43 *5·10*	*8·0*	6 × 3×·34 *6·80*	6 × 3×·37 *7·25*	6 × 3×·44 *8·20*	6 × 3×·48 *8·75*	*9·50*	7 × 3 × ·38 *10·25*	7 × 3 × ·43 *11·15*	7 × 3 × ·49 *12·25*	*13·35*
21	23¾	16·8	BULB ANGLES	5½×3 × ·34 *5·60*	*7·5*	6 × 3×·38 *7·35*	6 × 3×·42 *7·90*	6 × 3×·48 *8·75*	*9·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·42 *10·95*	7 × 3 × ·48 *12·05*	*12·95*	8 × 3 × ·39 *14·10*
22	24	17·6	BULB ANGLES	5½×3 × ·39 *6·15*	*7·0*	6 × 3×·42 *7·90*	6 × 3×·46 *8·45*	*9·50*	7 × 3×·37 *10·10*	7 × 3 × ·42 *10·95*	7 × 3 × ·47 *11·85*	*13·00*	8 × 3 × ·38 *13·85*	8 × 3 × ·45 *15·45*
23	24½	18·4	BULB ANGLES	6 × 3 × ·33 *6·65*	*6·6*	6 × 3×·47 *8·60*	*9·20*	7 × 3×·38 *10·25*	7 × 3×·42 *10·95*	7 × 3 × ·47 *11·85*	*12·75*	8 × 3 × ·38 *13·85*	8 × 3 × ·43 *15·00*	8 × 3 × ·49 *16·35*
24	25	19·2	BULB ANGLES	6 × 3 × ·37 *7·25*	*6·3*	*9·30*	7 × 3×·36 *9·95*	7 × 3×·42 *10·95*	7 × 3×·47 *11·85*	*12·70*	8 × 3 × ·37 *13·65*	8 × 3 × ·42 *14·75*	8 × 3 × ·48 *16·10*	*17·40*
25	25½	20·0	BULB ANGLES	6 × 3 × ·42 *7·90*	*6·0*	7 × 3×·37 *10·10*	7 × 3×·41 *10·80*	7 × 3×·47 *11·85*	*12·65*	8 × 3 × ·37 *13·65*	8 × 3 × ·41 *14·55*	8 × 3 × ·47 *15·90*	8 × 3½×·51 *16·95*	*18·55*
26	26	20·8	BULB ANGLES	6 × 3 × ·46 *8·45*	*5·8*	7 × 3×·42 *10·95*	7 × 3×·45 *11·50*	7 × 3×·52 *12·80*	*13·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·46 *15·65*	8 × 3 × ·51 *16·85*	*18·15*	9 × 3½×·43 *19·65*
27	26½	21·6	BULB ANGLES	6 × 3 × ·52 *9·30*	*5·6*	7 × 3×·47 *11·85*	7 × 3×·50 *12·40*	*13·70*	8 × 3×·41 *14·55*	8 × 3 × ·46 *15·65*	8 × 3 × ·50 *16·60*	*18·00*	9 × 3½×·42 *19·40*	9 × 3½×·48 *21·05*
28	27	22·4	BULB ANGLES	7 × 3 × ·36 *9·95*	*5·4*	7 × 3×·51 *12·60*	*13·30*	8 × 3×·42 *14·75*	8 × 3×·46 *15·65*	8 × 3½×·49 *16·45*	*17·75*	9 × 3½×·41 *19·15*	9 × 3½×·47 *20·80*	9 × 3½×·53 *22·45*
29	27½	23·2	BULB ANGLES	7 × 3 × ·41 *10·80*	*5·2*	*13·75*	8 × 3×·40 *14·30*	8 × 3×·46 *15·65*	8 × 3×·50 *16·60*	*17·75*	9 × 3½×·40 *18·90*	9 × 3½×·46 *20·50*	9 × 3½×·52 *22·20*	*24·00*
30	28	24·0	BULB ANGLES	7 × 3 × ·45 *11·50*	*5·0*	8 × 3×·42 *14·75*	8 × 3×·45 *15·45*	8×3½×·50 *16·70*	*17·75*	9 × 3½×·40 *18·90*	9 × 3½×·45 *20·20*	9 × 3½×·51 *21·90*	9 × 3½×·57 *23·60*	10×3½×·48 *25·80*

Section moduli above are given to nearest ·05

For notes see page 97

TABLE 12

(SEE CONTINUATION)

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					19	20	21	22	23	24	25	26
Feet	Inches	Feet	Per cent		INCHES *Modulus—Inches*³							
10	21	8·0	*15·0*	ANGLES								
11	21¼	8·8	*14·0*									
12	21½	9·6	*13·0*									
13	21¾	10·4	*12·0*									
14	22	11·2	*11·0*									
15	22¼	12·0	*10·5*		6 × 3 × ·43 *8·05*							
16	22½	12·8	*10·0*		6 × 3 × ·50 *9·00*	7 × 3 × ·35 *9·80*						
17	22¾	13·6	*9·5*		7 × 3 × ·37 *10·10*	7 × 3 × ·43 *11·15*	7 × 3 × ·48 *12·05*					
18	23	14·4	*9·0*		7 × 3 × ·45 *11·50*	7 × 3 × ·50 *12·40*	8 × 3 × ·37 *13·65*	8 × 3 × ·42 *14·75*				
19	23¼	15·2	*8·5*		7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·44 *15·20*	8 × 3 × ·50 *16·60*	8 × 3 × ·55 *17·80*			
20	23½	16·0	*8·0*		8 × 3 × ·41 *14·55*	8 × 3 × ·46 *15·65*	8 × 3 × ·52 *17·10*	*18·50*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*		
21	23¾	16·8	*7·5*	BULB ANGLES	8 × 3 × ·46 *15·65*	8 × 3 × ·51 *16·85*	*18·30*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	*24·70*	
22	24	17·6	*7·0*		8 × 3 × ·50 *16·60*	*18·00*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·55 *23·00*	*24·85*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·52 *28·10*
23	24½	18·4	*6·6*		*17·75*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·54 *22·70*	*24·55*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·59 *30·45*
24	25	19·2	*6·3*		9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·52 *22·20*	*24·10*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*	*32·55*
25	25½	20·0	*6·0*		9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·58 *23·85*	*25·60*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	*32·25*	11 × 3½ × ·52 *34·55*
26	26	20·8	*5·8*		9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	*25·25*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·56 *29·45*	*31·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·57 *36·60*
27	26½	21·6	*5·6*		9 × 3½ × ·55 *23·00*	*24·75*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	*31·40*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
28	27	22·4	*5·4*		*24·50*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*	*30·80*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*
29	27½	23·2	*5·2*		10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *80·45*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*
30	28	24·0	*5·0*		10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	*40·40*	12 × 3½ × ·54 *43·05*	12 × 3½ × ·61 *46·40*

Section moduli above are given to nearest ·05

For notes see page 97

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					27	28	29	30	31	32	33	34
Feet	Inches	Feet	Per cent		INCHES — Modulus—Inches³							
10	21	8·0	*15·0*	ANGLES								
11	$21\frac{1}{4}$	8·8	*14·0*	ANGLES								
12	$21\frac{1}{2}$	9·6	*13·0*	ANGLES								
13	$21\frac{3}{4}$	10·4	*12·0*	ANGLES								
14	22	11·2	*11·0*	BULB ANGLES								
15	$22\frac{1}{4}$	12·0	*10·5*	BULB ANGLES								
16	$22\frac{1}{2}$	12·8	*10·0*	BULB ANGLES								
17	$22\frac{3}{4}$	13·6	*9·5*	BULB ANGLES								
18	23	14·4	*9·0*	BULB ANGLES								
19	$23\frac{1}{4}$	15·2	*8·5*	BULB ANGLES								
20	$23\frac{1}{2}$	16·0	*8·0*	BULB ANGLES								
21	$23\frac{3}{4}$	16·8	*7·5*	BULB ANGLES								
22	24	17·6	*7·0*	BULB ANGLES								
23	$24\frac{1}{2}$	18·4	*6·6*	BULB ANGLES	*32·65*							
24	25	19·2	*6·3*	BULB ANGLES	11×3½×·52 *34·55*	11×3½×·58 *37·00*						
25	$25\frac{1}{2}$	20·0	*6·0*	BULB ANGLES	11×3½×·58 *37·00*	11×3½×·64 *39·40*	12×3½×·51 *41·65*	12×3½×·56 *44·00*				
26	26	20·8	*5·8*	BULB ANGLES	11×3½×·64 *39·40*	12×3½×·51 *41·65*	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·56 *49·40*			
27	$26\frac{1}{2}$	21·6	*5·6*	BULB ANGLES	12×3½×·51 *41·65*	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·63 *52·20*	*55·00*		
28	27	22·4	*5·4*	BULB ANGLES	12×3½×·56 *44·00*	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·64 *52·60*	*55·30*	*58·15*	15×4×4×·42 *60·95*	
29	$27\frac{1}{2}$	23·2	*5·2*	BULB ANGLES	12×3½×·62 *46·85*	12×4×4×·57 *49·80*	12×4×4×·64 *52·60*	*55·55*	*58·55*	15×4×4×·43 *61·55*	15×4×4×·48 *64·60*	15×4×4×·53 *67·65*
30	28	24·0	*5·0*	CH.	12×4×4×·56 *49·40*	12×4×4×·64 *52·60*	*55·50*	*58·75*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·54 *68·25*	15×4×4×·60 *71·80*

Section moduli above are given to nearest ·05

For notes see page 97

TABLE 12

(SEE CONTINUATION)

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET								
					8	10	12	13	14	15	16	17	18
Feet	Inches	Feet	INCHES *Modulus—Inches³*	Per cent	INCHES *Modulus—Inches³*								
31	28½	24·8	7 × 3 × ·51 *12·60*	*4·8*	8 × 3½ × ·47 *16·00*	8 × 3½ × ·50 *16·70*	*17·80*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·49 *27·10*
32	29	25·6	8 × 3 × ·38 *13·85*	*4·6*	8 × 3½ × ·51 *16·95*	*17·70*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*
33	29½	26·4	8 × 3 × ·44 *15·20*	*4·4*	*18·25*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*
34	30	27·2	8 × 3 × ·50 *16·60*	*4·3*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·45 *31·95*
35	30½	28·0	8 × 3 × ·55 *17·80*	*4·2*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·49 *33·45*
36	31	28·8	9 × 3½ × ·41 *19·15*	*4·1*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*
37	31½	29·4	9 × 3½ × ·45 *20·20*	*4·0*	9 × 3½ × ·56 *23·30*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·57 *29·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·57 *36·60*
38	32	30·0	*21·20*	*4·0*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
39	32½	30·0	*21·40*	*4·0*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·62 *31·45*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
40	33	30·0	9 × 3½ × ·50 *21·60*	*4·0*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·47 *39·90*
41	33½	30·0	*21·80*	*4·0*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·50 *41·20*
42	34	30·0	*22·00*	*4·0*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·52 *42·10*
43	34½	30·0	9 × 3½ × ·52 *22·20*	*4·0*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·55 *43·55*
44	35	30·0	*22·40*	*4·0*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·57 *29·80*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·57 *44·50*
45	35½	30·0	*22·60*	*4·0*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·47 *32·50*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·59 *45·45*
46	36	30·0	*22·80*	*4·0*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*
47	36½	30·0	9 × 3½ × ·55 *23·00*	*4·0*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·69 *39·40*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·57 *44·50*	12 × 3½ × ·64 *47·75*
48	37	30·0	*23·20*	*4·0*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·53 *42·60*	12 × 3½ × ·59 *45·45*	12 × 4 × 4 × ·54 *48·60*
49	37½	30·0	*23·40*	*4·0*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·64 *39·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*	12 × 4 × 4 × ·57 *49·80*
50	38	30·0	9 × 3½ × ·57 *23·60*	*4·0*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 3½ × ·64 *47·75*	12 × 4 × 4 × ·60 *51·00*

BULB ANGLES

Section moduli above are given to nearest ·05

For notes see page 97

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					19	20	21	22	23	24	25	26
Feet	Inches	Feet	Per cent		INCHES — Modulus—Inches³							
31	28½	24·8	4·8	BULB ANGLES	10×3½×·56 29·45		11×3½×·51 34·20	11×3½×·58 37·00	11×3½×·65 39·80	12×3½×·53 42·60	12×3½×·60 45·90	12×4×4×·54 48·60
32	29	25·6	4·6		10×3½×·61 31·15	11×3½×·49 33·45	11×3½×·56 36·20	11×3½×·64 39·40	12×3½×·52 42·10	12×3½×·59 45·45	12×4×4×·53 48·20	12×4×4×·61 51·40
33	29½	26·4	4·4		11×3½×·47 32·70	11×3½×·54 35·40	11×3½×·61 38·20	12×3½×·50 41·20	12×3½×·55 43·55	12×3½×·64 47·75	12×4×4×·60 51·00	12×4×4×·68 54·15
34	30	27·2	4·3		11×3½×·52 34·55	11×3½×·58 37·00	12×3½×·48 40·30	12×3½×·55 43·55	12×3½×·62 46·85	12×4×4×·58 50·20	12×4×4×·66 53·35	57·00
35	30½	28·0	4·2		11×3½×·56 36·20	11×3½×·63 39·00	12×3½×·52 42·10	12×3½×·59 45·45	12×4×4×·55 49·00	12×4×4×·64 52·60	56·05	60·00
36	31	28·8	4·1		11×3½×·59 37·40	12×3½×·49 40·75	12×3½×·56 44·00	12×4×4×·51 47·40	12×4×4×·60 51·00	54·95	58·80	15×4×4×·45 62·75
37	31½	29·4	4·0		11×3½×·65 39·80	12×3½×·53 42·60	12×3½×·61 46·40	12×4×4×·57 49·80	12×4×4×·67 53·75	57·40	15×4×4×·43 61·55	15×4×4×·49 65·25
38	32	30·0	4·0		12×3½×·49 40·75	12×3½×·56 44·00	12×3½×·64 47·75	12×4×4×·61 51·40	55·25	59·30	15×4×4×·46 63·35	15×4×4×·54 68·25
39	32½	30·0	4·0		12×3½×·52 42·10	12×3½×·59 45·45	12×4×4×·55 49·00	12×4×4×·64 52·60	56·50	60·50	15×4×4×·49 65·25	15×4×4×·56 69·45
40	33	30·0	4·0		12×3½×·54 43·05	12×3½×·61 46·40	12×4×4×·58 50·20	12×4×4×·68 54·15	57·80	15×4×4×·44 62·15	15×4×4×·50 65·85	15×4×4×·57 70·05
41	33½	30·0	4·0		12×3½×·57 44·50	12×3½×·64 47·75	12×4×4×·61 51·40	55·10	59·10	15×4×4×·45 62·75	15×4×4×·52 67·05	15×4×4×·60 71·80
42	34	30·0	4·0		12×3½×·59 45·45	12×4×4×·55 49·00	12×4×4×·65 53·00	56·40	60·30	15×4×4×·48 64·60	15×4×4×·55 68·85	15×4×4×·62 73·00
43	34½	30·0	4·0		12×3½×·62 46·85	12×4×4×·58 50·20	12×4×4×·67 53·75	57·70	15×4×4×·43 61·55	15×4×4×·49 65·25	15×4×4×·56 69·45	15×4×4×·64 74·20
44	35	30·0	4·0		12×3½×·64 47·75	12×4×4×·61 51·40	55·10	59·00	15×4×4×·45 62·75	15×4×4×·52 67·05	15×4×4×·59 71·25	15×4×4×·66 75·35
45	35½	30·0	4·0	CHANNELS	12×4×4×·55 49·00	12×4×4×·64 52·60	56·30	60·25	15×4×4×·47 64·00	15×4×4×·54 68·25	15×4×4×·61 72·40	76·90
46	36	30·0	4·0		12×4×4×·58 50·20	12×4×4×·67 53·75	57·60	15×4×4×·43 61·55	15×4×4×·50 65·85	15×4×4×·56 69·45	15×4×4×·63 73·60	78·20
47	36½	30·0	4·0		12×4×4×·61 51·40	54·90	58·80	15×4×4×·45 62·75	15×4×4×·51 66·45	15×4×4×·58 70·65	15×4×4×·65 74·80	79·45
48	37	30·0	4·0		12×4×4×·64 52·60	56·10	60·05	15×4×4×·47 64·00	15×4×4×·53 67·65	15×4×4×·60 71·80	76·05	17×4×4×·49 80·85
49	37½	30·0	4·0		12×4×4×·67 53·75	57·30	15×4×4×·43 61·55	15×4×4×·49 65·25	15×4×4×·56 69·45	15×4×4×·62 73·00	77·35	17×4×4×·50 81·60
50	38	30·0	4·0		54·70	58·50	15×4×4×·45 62·75	15×4×4×·51 66·45	15×4×4×·58 70·65	15×4×4×·64 74·20	78·60	17×4×4×·52 83·10

Section moduli above are given to nearest ·05

For notes see page 97

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET: 27	28	29	30	31	32	33	34
Feet	Inches	Feet	Per cent	INCHES *Modulus—Inches³*							
31	28½	24·8	4·8	12×4×4×·62 *51·80*	*55·30*	*58·55*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·60 *71·80*	15×4×4×·66 *75·35*
32	29	25·6	4·6	*54·95*	*58·45*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*79·60*
33	29½	26·4	4·4	*57·95*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·48 *80·05*	17×4×4×·52 *83·10*
34	30	27·2	4·3	*60·90*	15×4×4×·49 *65·25*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·45*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*
35	30½	28·0	4·2	15×4×4×·47 *64·00*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·40*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*
36	31	28·8	4·1	15×4×4×·52 *67·05*	15×4×4×·59 *71·25*	15×4×4×·66 *75·35*	*80·00*	17×4×4×·53 *83·85*	17×4×4×·58 *87·55*	17×4×4×·65 *92·75*	17×4×4×·72 *97·80*
37	31½	29·4	4·0	15×4×4×·57 *70·05*	15×4×4×·65 *74·80*	*79·00*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*
38	32	30·0	4·0	15×4×3×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·62 *90·50*	17×4×4×·69 *95·65*	17×4×4×·77 *101·35*	
39	32½	30·0	4·0	15×4×4×·63 *73·60*	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*		
40	33	30·0	4·0	15×4×4×·65 *74·80*	*79·25*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·66 *93·45*	17×4×4×·72 *97·80*		
41	33½	30·0	4·0	15×4×4×·67 *75·95*	*80·50*	17×4×4×·55 *85·35*	17×4×4×·61 *89·75*	17×4×4×·67 *94·20*	17×4×4×·74 *99·25*		
42	34	30·0	4·0	15×4×4×·69 *77·10*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·63 *91·25*	17×4×4×·69 *95·65*	17×4×4×·76 *100·65*		
43	34½	30·0	4·0	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*		
44	35	30·0	4·0	*79·60*	17×4×4×·53 *83·85*	17×4×4×·60 *89·00*	17×4×4×·66 *93·45*	17×4×4×·73 *98·55*			
45	35½	30·0	4·0	17×4×4×·49 *80·85*	17×4×4×·55 *85·35*	17×4×4×·62 *90·50*	17×4×4×·68 *94·90*	17×4×4×·74 *99·25*			
46	36	30·0	4·0	17×4×4×·51 *82·35*	17×4×4×·57 *86·85*	17×4×4×·63 *91·25*	17×4×4×·70 *96·35*	17×4×4×·76 *100·65*			
47	36½	30·0	4·0	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*				
48	37	30·0	4·0	17×4×4×·54 *84·60*	17×4×4×·60 *89·00*	17×4×4×·67 *94·20*	17×4×4×·73 *98·55*				
49	37½	30·0	4·0	17×4×4×·56 *86·10*	17×4×4×·62 *90·50*	17×4×4×·68 *94·90*					
50	38	30·0	4·0	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·70 *96·35*					

CHANNELS

Section moduli above are given to nearest ·05

NOTES.—TABLE 12

1. **Correction to modulus of peak framing.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by 9 per cent per foot of difference.

2. **Corrections to modulus of main framing.**—The Table modulus is to be corrected, if necessary, as follows :—

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR TANK SIDE BRACKETS AND BEAM KNEES

If the height of the tank side brackets above the inner bottom is greater than that derived from Tables 6 and 11 or the depth of the beam knees greater than that required by Table 28 the modulus may be reduced at the rate of 4 per cent per foot of difference.

If the height of the tank side brackets above the inner bottom is less than that derived from Tables 6 and 11 the modulus is to be increased at the rate of 8 per cent per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

3. For increase in boiler rooms and coal bunkers *see* D 614.

4. Particulars of sections and moduli are given in Table 56.

TABLE 13

'TWEEN DECK FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN d and d_b*	A	B	C	D	E	F
Feet	Inches	Feet	Per cent	INCHES *Modulus—Inches³*					
12	21½	9·6	*14·0*		3 × 2½ × ·28 *·90*	3 × 2½ × ·39 *1·30*			3 × 2½ × ·28 *·90*
14	22	11·2	*13·5*		3 × 3 × ·34 *1·15*	3½ × 3 × ·37 *1·60*			3 × 3 × ·30 *1·00*
16	22½	12·8	*13·0*		3½ × 3 × ·32 *1·40*	4 × 3 × ·36 *2·00*			3 × 3 × ·34 *1·15*
18	23	14·4	*12·5*		3½ × 3 × ·38 *1·65*	4 × 3 × ·45 *2·45*	5 × 3 × ·40 *3·30*		3 × 3 × ·40 *1·35*
20	23½	16·0	*12·0*		3½ × 3 × ·46 *2·00*	5 × 3 × ·36 *3·00*	5 × 3 × ·49 *4·05*		3½ × 3 × ·36 *1·55*
22	24	17·6	*11·4*		4 × 3 × ·43 *2·35*	5 × 3 × ·45 *3·70*	6 × 3 × ·40 *4·75*		4 × 3 × ·32 *1·80*
24	25	19·2	*10·8*	4 × 3 × ·41 *2·25*	5 × 3 × ·33 *2·80*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*		4 × 3 × ·37 *2·05*
26	26	20·8	*10·2*	4 × 3½ × ·50 *2·75*	5 × 3½ × ·39 *3·25*	6 × 3½ × ·47 *5·50*	6 × 3½ × ·31 *6·50*	6 × 3½ × ·48 *8·80*	4 × 3½ × ·44 *2·40*
28	27	22·4	*9·6*	5 × 3½ × ·40 *3·35*	5 × 3½ × ·45 *3·75*	6 × 3½ × ·33 *6·70*	6 × 3½ × ·40 *7·65*	7 × 3½ × ·39 *10·45*	5 × 3½ × ·34 *2·85*
30	28	24·0	*9·0*	5 × 3½ × ·48 *4·00*	6 × 3½ × ·38 *4·50*	6 × 3½ × ·43 *8·05*	6 × 3½ × ·50 *9·05*	7 × 3½ × ·48 *12·05*	5 × 3½ × ·41 *3·40*
32	29	25·6	*8·2*	6 × 3½ × ·40 *4·70*	6 × 3½ × ·47 *5·50*	*9·40*	7 × 3½ × ·43 *11·10*	8 × 3½ × ·38 *13·90*	5 × 3½ × ·48 *4·00*
34	30	27·2	*7·4*	6 × 3½ × ·47 *5·50*	6 × 3½ × ·31 *6·50*	7 × 3½ × ·43 *11·10*	*13·00*	8 × 3½ × ·47 *15·95*	6 × 3½ × ·40 *4·70*
36	31	28·8	*6·6*	6 × 3½ × ·31 *6·50*	6 × 3½ × ·40 *7·65*	7 × 3½ × ·53 *13·00*	8 × 3½ × ·45 *15·50*	9 × 3½ × ·38 *18·40*	6 × 3½ × ·46 *5·40*
38	32	30·0	*6·0*	6 × 3½ × ·39 *7·55*	6 × 3½ × ·48 *8·80*	8 × 3½ × ·43 *15·00*	8 × 3½ × ·54 *17·60*	9 × 3½ × ·46 *20·50*	6 × 3½ × ·53 *6·15*
40	33	30·0	*6·0*	6 × 3½ × ·42 *7·95*	*9·35*	8 × 3½ × ·47 *15·95*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	6 × 3½ × ·32 *6·60*
42	34	30·0	*6·0*	6 × 3½ × ·45 *8·35*	7 × 3½ × ·35 *9·80*	8 × 3½ × ·50 *16·70*	9 × 3½ × ·43 *19·65*	*23·65*	6 × 3½ × ·36 *7·10*
44	35	30·0	*6·0*	6 × 3½ × ·49 *8·90*	7 × 3½ × ·39 *10·45*	*17·75*	9 × 3½ × ·48 *21·05*	10 × 3½ × ·43 *25·10*	6 × 3½ × ·40 *7·65*
46	36	30·0	*6·0*	*9·35*	7 × 3½ × ·42 *10·95*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·48 *26·75*	6 × 3½ × ·44 *8·20*
48	37	30·0	*6·0*	7 × 3½ × ·35 *9·80*	7 × 3½ × ·45 *11·50*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·53 *28·45*	6 × 3½ × ·47 *8·65*
50	38	30·0	*6·0*	7 × 3½ × ·38 *10·25*	7 × 3½ × ·47 *11·85*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·57 *29·80*	6 × 3½ × ·51 *9·20*

ANGLES

BULB ANGLES

ANGLES

BULB ANGLES

Section moduli above are given to nearest ·05

For notes see page 99

TABLE 13

'TWEEN DECK FRAMING

NOTES.—TABLE 13

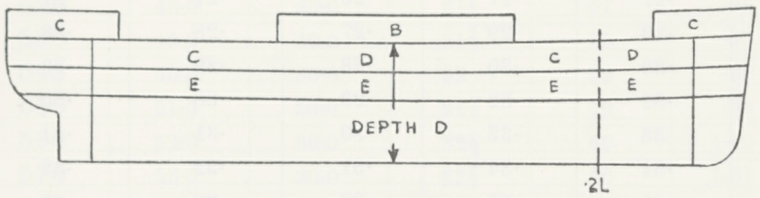


Diagram I

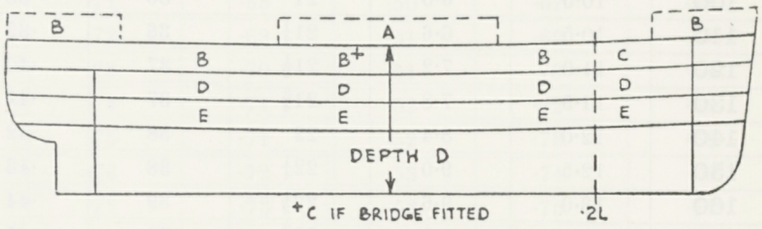


Diagram II

1. **Scantlings.**—The scantlings of the 'tween deck frames are given in cols. A to F. The positions to which each column between A and E applies are shown in the diagrams ; for col. F *see* note 3. The scantlings given in the Table apply to frames fitted at every frame.

Diagram I is to be used when the ratio of draught d to depth D exceeds ·75.

Diagram II is to be used when the ratio of draught d to depth D is—

less than ·68 when D exceeds 22 feet

„ „ ·60 „ D is 18 feet ;

intermediate values to be obtained by interpolation.

When the value of the ratio d|D falls between the limits defined above the scantlings of the framing are to be determined by interpolation.

2. **Corrections to modulus of framing.**

FOR DRAUGHT

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height at side is greater than 8 feet 6 inches, modulus to be increased in direct proportion.

3. If the framing in a 'tween deck consists of alternate frames extended from below with intermediate frames the mean modulus per frame space is to be as required for uniform framing, but the modulus of the intermediate frames is not to be less than that given in col. F. If frames are fitted two spaces apart (*see* D 609) the mean modulus per frame space is to be maintained.

4. Where several tiers of superstructures are fitted the scantlings and arrangements of the framing will be specially considered.

5. For increase in 'tween deck bunkers *see* D 614.

6. Particulars of sections and moduli are given in Table 56.

TABLE 14

(SEE CONTINUATION)

SHELL PLATING

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS	WIDTH OF FLAT PLATE KEEL	THICKNESS OF FLAT PLATE KEEL	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05 L FROM ENDS	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS	
						FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE		FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE
1	2	3	4	5	6	7	8	9	10	11
Feet	Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	10·0	6·0	21	36	·38	·26	·26	·25	·26	·26
110	10·5	6·6	21¼	36	·39	·27	·27	·26	·27	·27
120	11·0	7·2	21½	37	·40	·29	·29	·27	·28	·28
130	11·5	7·8	21¾	37	·41	·30	·30	·28	·29	·29
140	12·0	8·4	22	38	·42	·32	·32	·29	·30	·30
150	12·5	9·0	22¼	38	·43	·33	·33	·30	·31	·31
160	13·0	9·6	22½	39	·44	·34	·34	·31	·32	·32
170	13·5	10·2	22¾	39	·45	·35	·35	·32	·33	·33
180	14·0	10·8	23	40	·47	·36	·36	·33	·34	·34
190	15·0	11·4	23¼	40	·48	·37	·37	·34	·35	·35
200	16·0	12·0	23½	41	·50	·38	·38	·34	·36	·36
210	17·0	12·6	23¾	41	·51	·39	·39	·35	·37	·37
220	18·0	13·2	24	42	·52	·40	·40	·35	·38	·38
230	19·0	13·8	24¼	42	·53	·41	·41	·36	·39	·39
240	20·0	14·4	24½	43	·55	·42	·42	·37	·40	·40
250	21·0	15·0	24¾	43	·56	·43	·43	·37	·41	·41
260	22·0	15·6	25	44	·57	·44	·44	·38	·42	·42
270	23·0	16·2	25¼	44	·58	·45	·45	·38	·42	·42
280	24·0	16·8	25½	45	·60	·46	·46	·39	·43	·43
290	25·0	17·4	25¾	45	·61	·47	·47	·39	·43	·43
300	26·0	18·0	26	46	·63	·48	·48	·40	·44	·44
310	27·0	18·6	26¼	46	·64	·49	·49	·40	·44	·44
320	28·0	19·2	26½	47	·66	·50	·50	·41	·45	·45
330	29·0	19·8	26¾	47	·67	·51	·51	·41	·46	·46
340	30·0	20·4	27	48	·69	·52	·52	·42	·47	·47
350	31·0	21·0	27¼	48	·70	·53	·53	·42	·48	·48
360	32·0	21·6	27½	49	·72	·54	·54	·43	·49	·49
370	33·0	22·2	27¾	49	·74	·55	·55	·43	·50	·50
380	34·0	22·8	28	50	·76	·56	·56	·44	·51	·51
390	35·0	23·4	28¼	50	·77	·57	·56	·44	·52	·52
400	36·0	24·0	28½	51	·79	·58	·57	·45	·53	·53
410	37·0	24·6	28¾	51	·80	·59	·58	·45	·54	·54
420	38·0	25·2	29	52	·82	·60	·59	·46	·55	·55
430	39·0	25·8	29¼	52	·83	·61	·60	·46	·56	·56
440	40·0	26·4	29½	53	·85	·63	·61	·47	·57	·57
450	41·0	27·0	29¾	53	·86	·64	·62	·47	·58	·58
460	42·0	27·6	30	54	·88	·66	·63	·48	·59	·59
470	43·0	28·2	30¼	54	·89	·67	·64	·48	·60	·60
480	44·0	28·8	30½	55	·91	·68	·65	·49	·62	·62
490	45·0	29·4	30¾	55	·92	·69	·66	·49	·64	·63
500	46·0	30·0	31	56	·94	·70	·67	·50	·66	·65

For notes see page 101

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS	WIDTH OF FLAT PLATE KEEL	THICKNESS OF FLAT PLATE KEEL	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05L FROM ENDS	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS	
						FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE		FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE
1	2	3	4	5	6	7	8	9	10	11
Feet	Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
510	47·0	30·0	31¼	57	·95	·71	·68	·50	·67	·66
520	48·0	30·0	31½	57	·96	·72	·69	·51	·69	·67
530	49·0	30·0	31¾	58	·97	·73	·70	·51	·70	·68
540	50·0	30·0	32	59	·98	·74	·71	·52	·72	·69
550	51·0	30·0	32¼	59	·99	·75	·71	·52	·73	·69
560	52·0	30·0	32½	60	1·00	·76	·72	·53	·74	·70
570	53·0	30·0	32¾	60	1·01	·77	·73	·53	·75	·71
580	54·0	30·0	33	61	1·03	·78	·74	·54	·76	·72
590	55·0	30·0	33¼	61	1·04	·79	·74	·55	·77	·72
600	56·0	30·0	33½	62	1·06	·80	·75	·56	·78	·73
610	57·0	30·0	33¾	63	1·07	·81	·75	·56	·79	·73
620	58·0	30·0	34	63	1·08	·82	·76	·57	·80	·74
630	59·0	30·0	34¼	64	1·09	·83	·77	·57	·81	·75
640	60·0	30·0	34½	65	1·11	·84	·78	·58	·82	·76
650	61·0	30·0	34¾	65	1·12	·85	·78	·58	·83	·77

NOTES.—TABLE 14

1. **Keel.**—The width and thickness of the keel plate (cols. 5 and 6) are to be maintained throughout.

2. **Garboard strake**—If a bar keel is fitted, the thickness of the garboard strake is to be 85 per cent of that required for keel plate (col. 6) ; this thickness is to be maintained for ·4L amidships and may be 85 per cent of the amidships thickness for ·05L at the ends, but in way of strengthening of bottom forward is not to be less than required for bottom plating.

3. **Bottom and side plating.**—The Table thickness of bottom and side plating for ·4L amidships (cols. 7 and 8) is to be corrected, if necessary, as follows :—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 0·7 per cent per foot of difference.

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, thickness to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by 1·5 per cent per foot of difference.

If both these corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth*+1·22%; *correction for draught*—3·37%; *total factor* 1·012×·966=·978.)

The thickness for ·05 L at ends given in col. 9 are not subject to the above corrections.

4. **Effective superstructure.**—If an effective superstructure as defined in D 206 is fitted the shell plating may be modified as stated in D 703.

5. **Frame spacing.**—If the spacing amidships differs from the Table spacing (col. 4) the thickness of bottom and side plating is to be modified at the rate of ·01 inch for every inch of difference.

Where the bottom is framed longitudinally the thickness of the bottom shell plating is to be modified at the same rate for every inch of difference of spacing from that given in Table 10.

6. **Minimum thickness**—The thickness of the bottom and side plating for ·4L amidships, after correction as required by notes 3 and 5, is not to be less than that given in cols. 10 and 11, corrected as required by note 5 only.

7. **Local strengthening.**—Plates connected to the sternframe or propeller brackets are to have the thickness given in col. 8 without corrections and those which require to be furnaced are to be of that thickness when finished.

For strengthening of bottom forward *see* D 802.

For strengthening at openings in shell *see* D 705 to D 706.

For strengthening at ends of superstructures *see* D 1205 and D 1305 to D 1308.

For strengthening for navigation in ice *see* D 1005.

TABLE 15

BEAMS IN PEAKS BELOW LOWEST DECK

BREADTH B		BEAM	KNEE	RIVETS	
Feet		Inches	Inches	Number	Inches
22	BULB ANGLES	5 ×3 ×·28	15 ×·30	4	$\frac{3}{4}$
26	BULB ANGLES	5 ×3 ×·32	15 ×·32	4	$\frac{3}{4}$
30	BULB ANGLES	$5\frac{1}{2}$ ×3 ×·34	$16\frac{1}{2}$ ×·34	5	$\frac{3}{4}$
34	BULB ANGLES	6 ×3 ×·36	18 ×·34	6	$\frac{3}{4}$
38	CHANNELS	6 ×3 ×3 ×·32	20 ×·36	6	$\frac{3}{4}$
42	CHANNELS	6 ×3 ×3 ×·42	22 ×·38	6	$\frac{7}{8}$
46	CHANNELS	7 ×3 ×3 ×·40	24 ×·38	6	$\frac{7}{8}$
50	CHANNELS	8 ×3 ×3 ×·44	26 ×·40	6	$\frac{7}{8}$
54	CHANNELS	8 ×$3\frac{1}{2}$ ×$3\frac{1}{2}$ ×·40	28 ×·42	7	$\frac{7}{8}$

NOTE.—TABLE 15

Where B is greater than 54 feet the scantlings of the beams are to be specially considered in relation to the size and form of the ship.

TABLE 16

STRINGERS IN PANTING REGION

LENGTH L	FORWARD OF COLLISION BULKHEAD		ABAFT COLLISION BULKHEAD	
	STRINGER PLATE		THICKNESS OF INTERCOSTAL PLATE	FACE ANGLE
	WIDTH	THICKNESS		
Feet	Inches	Inches	Inches	Inches
100	22	·26	·28	ANGLES: $2\frac{1}{2} \times 2\frac{1}{2} \times ·30$
200	25	·29	·31	ANGLES: $3 \times 3 \times ·36$
300	28	·32	·35	ANGLES: $4\frac{1}{2} \times 3 \times ·40$
400	32	·35	·39	ANGLES: $6 \times 3\frac{1}{2} \times ·42$
500	36	·38	·42	BULB ANGLES: $7 \times 3\frac{1}{2} \times ·42$
600	40	·41	·46	BULB ANGLES: $8 \times 3\frac{1}{2} \times ·48$

TABLE 17

ICE STRENGTHENING
INTERMEDIATE FRAMES

LENGTH L	INTERMEDIATE FRAME	
	FORWARD OF COLLISION BULKHEAD	ABAFT COLLISION BULKHEAD
Feet	Inches	Inches
200	ANGLES: $3 \times 3 \times ·36$	ANGLE: $5 \times 3 \times ·42$
250	ANGLES: $3\frac{1}{2} \times 3 \times ·40$	BULB ANGLES: $5 \times 3 \times ·36$
300	ANGLES: $4 \times 3 \times ·48$	BULB ANGLES: $5\frac{1}{2} \times 3 \times ·40$
350	ANGLES: $5 \times 3 \times ·46$	BULB ANGLES: $6 \times 3 \times ·42$
400	ANGLES: $6 \times 3\frac{1}{2} \times ·44$	BULB ANGLES: $7 \times 3\frac{1}{2} \times ·36$
450	ANGLES: $7 \times 3\frac{1}{2} \times ·44$	BULB ANGLES: $7 \times 3\frac{1}{2} \times ·50$

TABLE 18

(*SEE CONTINUATION*)

TOPSIDE SCANTLINGS

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS	SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17) WHERE ONE DECK FITTED.		
							SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN* D *and* D_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN* d *and* d_b
1	2	3	4	5	6	7	8	9	10
Feet	Feet	Feet	Feet	Inches	Inches	Inches	Square inches	Per cent	Per cent
100	25	10	6·0	21	42	·28	9	*18·40*	*21·00*
110	26	10·5	6·6	21¼	42	·29	10	*15·90*	*20·10*
120	27	11	7·2	21½	43	·30	12	*14·30*	*19·20*
130	28	11·5	7·8	21¾	44	·32	13	*13·15*	*18·40*
140	29	12	8·4	22	45	·34	15	*12·25*	*17·60*
150	30	12·5	9·0	22¼	45	·36	18	*11·45*	*16·70*
160	31	13	9·6	22½	46	·37	21	*10·80*	*15·90*
170	32	13·5	10·2	22¾	46	·38	24	*10·20*	*15·10*
180	33	14	10·8	23	47	·40	27	*9·70*	*14·30*
190	34	15	11·4	23¼	48	·41	29	*9·25*	*13·55*
200	35	16	12·0	23½	49	·43	32	*8·80*	*12·80*
210	36	17	12·6	23¾	50	·44	35	*8·40*	*12·10*
220	37	18	13·2	24	51	·45	38	*8·00*	*11·40*
230	38	19	13·8	24¼	51	·46	41	*7·70*	*10·75*
240	39	20	14·4	24½	52	·47	45	*7·40*	*10·10*
250	40	21	15·0	24¾	52	·48	49	*7·20*	*9·50*
260	41	22	15·6	25	53	·50	54	*6·95*	*8·95*
270	42	23	16·2	25¼	53	·51	59	*6·70*	*8·45*
280	43	24	16·8	25½	54	·53	65	*6·50*	*7·90*
290	44	25	17·4	25¾	54	·54	71	*6·35*	*7·50*
300	45	26	18·0	26	55	·55	78	*6·15*	*7·10*
310	46	27	18·6	26¼	55	·56	84	*6·00*	*6·70*
320	47	28	19·2	26½	56	·57	91	*5·85*	*6·30*
330	48	29	19·8	26¾	56	·58	99	*5·70*	*5·95*
340	49	30	20·4	27	57	·59	106	*5·55*	*5·60*
350	50	31	21·0	27¼	57	·60	114	*5·40*	*5·30*
360	51	32	21·6	27½	58	·61	123	*5·25*	*5·05*
370	52	33	22·2	27¾	58	·63	131	*5·10*	*4·80*
380	53	34	22·8	28	59	·64	140	*4·95*	*4·60*
390	54	35	23·4	28¼	59	·65	150	*4·80*	*4·45*
400	55	36	24·0	28½	60	·67	160	*4·70*	*4·30*
410	56	37	24·6	28¾	60	·68	170	*4·55*	*4·20*
420	57	38	25·2	29	61	·70	180	*4·40*	*4·15*
430	58	39	25·8	29¼	61	·71	191	*4·30*	*4·10*
440	59	40	26·4	29½	62	·73	201	*4·20*	*4·05*
450	60	41	27·0	29¾	62	·74	213	*4·10*	*4·00*
460	61	42	27·6	30	63	·75			
470	62	43	28·2	30¼	63	·76			
480	63	44	28·8	30½	64	·78			
490	64	45	29·4	30¾	64	·79			
500	65	46	30·0	31	65	·80			

For notes see pages 106 & 107

SECTIONAL AREA OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS		LENGTH L
WHERE TWO DECKS FITTED			WHERE THREE DECKS FITTED			ALL STRENGTH DECKS					
SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* D *and* D_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* d *and* d_b	SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* D *and* D_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:* d *and* d_b	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN* B *and* B_b	OUTSIDE LINE OF OPENINGS	INSIDE LINE OF OPENINGS	STRINGER	PLATING	
11	12	13	14	15	16	17	18	19	20	21	22
Square inches	Per cent	Per cent	Square inches	Per cent	Per cent	Per cent	Inches	Inches	Inches	Inches	Feet
						4·0	·26	·26	·26	·26	100
						4·0	·26	·26	·26	·26	110
						4·0	·27	·26	·27	·26	120
						4·0	·27	·27	·27	·26	130
						4·0	·28	·27	·28	·26	140
						4·0	·28	·27	·28	·26	150
						4·0	·29	·28	·29	·27	160
						4·0	·30	·28	·29	·27	170
25	*13·65*	*11·20*				*4·0*	·31	·28	·30	·27	180
27	*13·10*	*11·05*				*4·0*	·31	·28	·30	·27	190
30	*12·50*	*10·90*				*4·0*	·32	·29	·31	·28	200
32	*12·00*	*10·70*				*4·0*	·32	·29	·31	·28	210
34	*11·50*	*10·50*				*4·0*	·33	·29	·32	·28	220
37	*11·00*	*10·35*				*4·0*	·33	·29	·32	·28	230
40	*10·55*	*10·15*				*4·0*	·34	·30	·33	·29	240
43	*10·05*	*9·95*				*4·0*	·34	·30	·33	·29	250
47	*9·60*	*9·70*				*4·0*	·35	·31	·34	·29	260
51	*9·25*	*9·45*				*4·0*	·35	·31	·34	·29	270
55	*8·95*	*9·20*				*4·0*	·36	·32	·35	·30	280
59	*8·70*	*8·85*				*4·0*	·36	·32	·35	·30	290
64	*8·45*	*8·50*				*4·0*	·37	·33	·36	·30	300
69	*8·20*	*8·05*				*3·9*	·37	·33	·36	·30	310
75	*8·00*	*7·60*				*3·8*	·38	·34	·37	·31	320
80	*7·80*	*7·15*				*3·7*	·38	·34	·37	·31	330
85	*7·65*	*6·75*	81	*9·50*	*7·05*	*3·6*	·39	·34	·38	·31	340
91	*7·50*	*6·40*	87	*9·10*	*6·70*	*3·5*	·39	·34	·38	·31	350
98	*7·30*	*6·05*	94	*8·70*	*6·35*	*3·4*	·40	·35	·39	·32	360
105	*7·10*	*5·70*	100	*8·35*	*6·05*	*3·3*	·40	·35	·39	·32	370
113	*6·90*	*5·45*	107	*8·05*	*5·75*	*3·2*	·41	·35	·39	·32	380
120	*6·75*	*5·20*	113	*7·80*	*5·50*	*3·1*	·41	·35	·39	·32	390
128	*6·60*	*5·00*	121	*7·55*	*5·30*	*3·0*	·42	·36	·40	·33	400
135	*6·40*	*4·80*	129	*7·35*	*5·10*	*2·9*	·43	·36	·40	·33	410
144	*6·20*	*4·65*	137	*7·20*	*4·95*	*2·8*	·44	·36	·40	·33	420
152	*6·00*	*4·50*	146	*7·05*	*4·80*	*2·7*	·44	·36	·40	·33	430
161	*5·85*	*4·40*	153	*6·95*	*4·70*	*2·6*	·45	·37	·41	·34	440
170	*5·70*	*4·30*	161	*6·80*	*4·55*	*2·5*	·45	·37	·41	·34	450
179	*5·50*	*4·20*	169	*6·70*	*4·45*	*2·4*	·46	·37	·41	·34	460
189	*5·30*	*4·15*	177	*6·60*	*4·40*	*2·3*	·46	·37	·41	·34	470
199	*5·10*	*4·10*	185	*6·50*	*4·30*	*2·2*	·47	·38	·42	·34	480
209	*4·95*	*4·05*	193	*6·40*	*4·25*	*2·1*	·47	·38	·42	·34	490
219	*4·80*	*4·00*	201	*6·30*	*4·20*	*2·0*	·48	·38	·42	·35	500

For notes see pages 106 to 108

TABLE 18

(SEE CONTINUATION)

TOPSIDE SCANTLINGS

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS	SECTIONAL AREAS OF STRENGTH DECK FOR ·4 L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17)		
							WHERE ONE DECK FITTED		
							SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN*	
								D *and* D_b	d *and* d_b
1	2	3	4	5	6	7	8	9	10
Feet	Feet	Feet	Feet	Inches	Inches	Inches	Square inches	Per cent	Per cent
510	66	47	30·0	$31\frac{1}{4}$	65	·81			
520	67	48	30·0	$31\frac{1}{2}$	66	·82			
530	68	49	30·0	$31\frac{3}{4}$	66	·82			
540	69	50	30·0	32	67	·83			
550	70	51	30·0	$32\frac{1}{4}$	67	·84			
560	71	52	30·0	$32\frac{1}{2}$	68	·85			
570	72	53	30·0	$32\frac{3}{4}$	68	·85			
580	73	54	30·0	33	69	·86			
590	74	55	30·0	$33\frac{1}{4}$	69	·87			
600	75	56	30·0	$33\frac{1}{2}$	70	·87			
610	76	57	30·0	$33\frac{3}{4}$	71	·88			
620	77	58	30·0	34	72	·89			
630	78	59	30·0	$34\frac{1}{4}$	73	·89			
640	79	60	30·0	$34\frac{1}{2}$	74	·90			
650	80	61	30·0	$34\frac{3}{4}$	75	·90			

NOTES.—TABLE 18

1. Sheerstrake.—(*a*) The Table thickness of the sheerstrake (col. 7) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 4 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, thickness to be $\frac{\text{increased}}{\text{reduced}}$ by 4 per cent per foot of difference.

If both corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +7·32%; *correction for draught* −10·16%; *total factor*=1·073×·898=·964.)

(*b*) The thickness of sheerstrake is not to be corrected for frame spacing, but is not to be less, for ·4L amidships, than the side plating.

The thickness of sheerstrake at ends is to be the same as that of the side plating except in ships in which the draught does not exceed ·7D (D being measured to the uppermost continuous deck) when the end thickness may be as required for a poop or forecastle aft or forward respectively.

2. Plated strength deck.—(*a*) The area given in cols. 8, 11 and 14 is the sectional area of deck plating including stringer plate and stringer angle for one side of the ship abreast openings. If riveted overlap seams are fitted, they may be included in determining the required deck thickness.

(*b*) The Table area (cols. 8, 11 and 14) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, area to be $\frac{\text{reduced}}{\text{increased}}$ by the given percentage (cols. 9, 12 and 15) per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (cols. 10, 13 and 16) per foot of difference.

FOR BREADTH.

If B is $\frac{\text{greater}}{\text{less}}$ than B_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (col. 17) per foot of difference.

If more than one of the above corrections is required the factors derived from the individual corrections are to be multiplied together and not applied separately to the Table area. (*Example* : *Correction for depth* − 13·81% ; *correction for draught* + 3·92% ; *correction for breadth* + 9·12% ; *total factor* = ·862 × 1·039 × 1·091 = ·978.)

(SEE CONTINUATION)

SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS		LENGTH L
WHERE TWO DECKS FITTED			WHERE THREE DECKS FITTED			ALL STRENGTH DECKS					
SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:*		SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:*		*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN*	OUTSIDE LINE OF OPENINGS	INSIDE LINE OF OPENINGS	STRINGER	PLATING	
	D *and* D_b	d *and* d_b		D *and* D_b	d *and* d_b	B *and* B_b					
11	12	13	14	15	16	17	18	19	20	21	22
Square inches	Per cent	Per cent	Square inches	Per cent	Per cent	Per cent	Inches	Inches	Inches	Inches	Feet
227	*4·55*	*4·00*	209	*5·95*	*4·20*	*2·0*	·48	·38	·42	·35	510
237	*4·30*	*4·00*	217	*5·55*	*4·20*	*2·0*	·49	·39	·43	·35	520
246	*4·05*	*4·00*	225	*5·20*	*4·20*	*2·0*	·49	·39	·43	·35	530
256	*3·80*	*4·00*	233	*4·90*	*4·20*	*2·0*	·50	·39	·43	·35	540
265	*3·60*	*4·00*	241	*4·60*	*4·20*	*2·0*	·50	·39	·43	·35	550
273	*3·45*	*4·00*	249	*4·35*	*4·20*	*2·0*	·50	·40	·44	·36	560
			257	*4·10*	*4·20*	*2·0*	·50	·40	·44	·36	570
			266	*3·85*	*4·20*	*2·0*	·50	·40	·44	·36	580
			274	*3·65*	*4·20*	*2·0*	·50	·40	·44	·36	590
			282	*3·50*	*4·20*	*2·0*	·50	·41	·45	·36	600
			290	*3·35*	*4·20*	*2·0*	·50	·41	·45	·36	610
			299	*3·25*	*4·20*	*2·0*	·50	·41	·45	·37	620
			307	*3·15*	*4·20*	*2·0*	·50	·41	·45	·37	630
			315	*3·10*	*4·20*	*2·0*	·50	·42	·46	·37	640
			325	*3·00*	*4·20*	*2·0*	·50	·42	·46	·37	650

NOTES.—TABLE 18 *(continued)*

The deck area obtained after the above corrections is the minimum area. This area may require to be increased for special characteristics in design as required in note 2(*c*). (For longitudinal framing *see* note 3.)

(*c*) Where there is no effective superstructure (*see* D 206) on the strength deck, the sectional area of the strength deck plating as computed from notes 2(*a*) and 2(*b*) is to be increased by multiplying the area by the factor

$$F = \frac{L \times C_b}{100 \times d} \times f,$$ if this factor is greater than unity.

Where C_b = moulded block coefficient at load draught.

L = length between perpendiculars, in feet.

d = summer draught, in feet, measured from top of keel.

f is to be determined in the following manner :—

Where l = length, in feet, of machinery space between main bulkheads including mean length of adjacent cross bunkers, if any.

x = distance, in feet, of centre of the length 'l' from midships.

m = weight of machinery, in tons, excluding propellers and shafting, but including all auxiliary machinery in machinery space.

W = load displacement, in tons.

V = sea speed, in knots.

s = product of length, mean breadth and height, in feet, of cargo space in forecastle, poop or after 'tween decks as defined below.

z = distance, in feet, of centre of length of above cargo space from amidships.

Then f is the algebraic summation of the following terms "a" and "b" in all cases and "c" where applicable, multiplied by $\frac{1 + \frac{V^2}{L}}{1{\cdot}5}$

"a" "b" and "c" are obtained as follows:—

"a" is taken from Table 18A for the appropriate values of l/L and x/L.

"b" is calculated from Table 18B to give effect to any departure from a standard value of m/W = ·06, and may be positive or negative.

"c". If a forecastle and/or poop is fitted on the continuous strength deck for the carriage of cargo, or if cargo is carried in the upper 'tween decks

NOTES.—TABLE 18 (*concluded*).

abaft ·05L forward of the after perpendicular, a further term "c" is to be calculated and added as follows:—

For a forecastle, poop and/or after 'tween deck

$$\frac{3{\cdot}8\ s\ (z - {\cdot}25\ l - {\cdot}2L)}{WL}$$

(NOTE.—In calculating "s" for an after 'tween deck the length of the space need only be measured abaft ·05L forward of the after perpendicular.)

(*d*) Where a long continuous deckhouse extending over at least ·15L amidships and not less in breadth than ·8B is fitted, the increased deck area required by note 2(*c*) may extend from a distance of ·04L inside the deckhouse at each end to ·2L from midships. Within the remainder of the deckhouse the deck area is to be that required by note 2(*b*). (For Deckhouses *see* D 1207 to D 1210).

(*e*) The requirements of notes 2 (*c*) and 2 (*d*) may be modified as necessary to take account of any special features in the design arrangements not covered by the formula.

3. **Longitudinal framing.**—Where the strength deck is framed longitudinally, the sectional area of deck plating including stringer plate and stringer angle may be 10 per cent less than that obtained by Note 2. The associated basic total area of longitudinals is to be 20 per cent of the sectional area so obtained.

If the total area of longitudinals fitted exceeds the basic area, 75 per cent of the excess may be deducted from the area of deck plating, but the thickness must not be less than required by column 18. If the total area of longitudinals fitted is less than the basic area, the whole deficiency in area is to be added to the area of deck plating.

4. **'Tween deck height.**—If the midship height of the 'tween decks below the strength deck exceeds 8 feet 6 inches at side, the area of the strength deck, corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) is to be increased at the rate of 5 per cent of the Rule area of the second deck in two deck ships, and 7 per cent of the Rule area of the second deck in three-deck ships, per foot increase in 'tween deck height. If the second 'tween deck height exceeds 8 feet 6 inches, a further increase may be required.

If the midship height of the 'tween decks below the strength deck is less than 8 feet 6 inches at side, the area of the strength deck corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) máy be reduced at the rate of 5 per cent of the Rule area of the second deck per foot reduction in 'tween deck height.

5. **Beam spacing.**—If the spacing of beams amidships differs from that given in col. 5, or with longitudinal framing from that given in Table 26, the minimum thickness of deck plating outside line of openings (col. 18) is to be modified at the rate of ·01 inch for every 2 inches of difference, and the minimum thickness of deck plating inside line of openings (col. 19) at the rate of ·01 inch for each complete 4 inches.

6. **Stringer plates.**—The thickness of strength deck stringer plates amidships is not to be less than 85 per cent of the thickness of sheerstrake, corrected as required by note 1, nor less than ·04 inch greater than that given in col. 18.

The width of stringer plates for ·1L at ends is not to be less than 60 per cent of the width amidships (col. 6).

7. **Stringer angles.**—Scantlings are to be in accordance with Table 19.

8. **Sheathed decks.**—Where plated decks are sheathed with wood or approved composition the thickness given in col. 18 may be reduced by 15 per cent in ships over 170 feet in length and by 10 per cent in smaller ships, and that given in cols. 19, 20 and 21 may be reduced by 10 per cent for all ships.

9. **Effective superstructures.**—If an effective superstructure as defined in D 206 is fitted amidships the scantlings of the upper and second decks in way of the superstructure are to be those required for the second and third decks respectively.

10. **Strength deck with stringers and tie plates.**—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

The width of stringer plates for ·4L amidships is not to be less than 22 inches and 54 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion.

The thickness of the stringer and tie plates is not to be less than given in col. 20, but stringer plates for ·4L amidships are not to be less than 85 per cent of the Rule thickness of sheerstrake.

11. **Local strengthening.**—For strengthening at the ends of superstructures *see* D 1205 and D 1305 to D 1308.

For strengthening at openings *see* D 1108.

For strengthening in ships having concentrated loading amidships *see* D 1107.

TABLE 18A

Term "a" of Basic Deck Factor f (Note 2 (c)) for $m/W = \cdot 06$

l/L	x/L					
	·02	·04	·06	·08	·10	·12
·11	5·85	5·65	5·34	4·84	4·11	3·06
·12	6·42	6·22	5·91	5·40	4·69	3·78
·13	6·96	6·75	6·42	5·94	5·34	4·50
·14	7·46	7·26	6·96	6·49	5·91	5·18
·15	7·92	7·74	7·45	6·99	6·48	5·83
·16	8·38	8·16	7·90	7·48	7·00	6·48
·17	8·80	8·59	8·32	7·95	7·54	7·06
·18	9·18	8·98	8·71	8·40	8·04	7·63
·19	9·54	9·35	9·08	8·79	8·47	8·12
·20	9·85	9·66	9·45	9·17	8·88	8·56
·21	10·14	9·95	9·74	9·48	9·20	8·93

TABLE 18B

Term "b" of Basic Deck Factor f (Note 2(c))

Value per ·01 Difference in m/W from ·06

x/L	CORRECTION	x/L	CORRECTION
·0	·526	·06	·440
·01	·522	·07	·412
·02	·514	·08	·380
·03	·502	·09	·345
·04	·486	·10	·312
·05	·464	·11	·277
		·12	·242

The term "b" is $\begin{matrix}\text{positive}\\\text{negative}\end{matrix}$ when m/W is $\begin{matrix}\text{less}\\\text{greater}\end{matrix}$ than ·06.

TABLE 19

STRINGER ANGLES ON STRENGTH DECKS

THICKNESS OF SHEERSTRAKE OR STRINGER PLATE WHICHEVER IS THE GREATER		DIAMETER OF RIVET AS REQUIRED BY TABLE 52	SIZES OF FLANGES *	SPACING OF RIVETS
Above	not exceeding	Inches	Inches	Diameters
Inches				
—	·36	$\frac{5}{8}$	3 × 3	$4\frac{1}{2}$
·36	·50	$\frac{3}{4}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·50	·56	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·56	·64	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·64	·72	$\frac{7}{8}$	5 × 5	2 rows, 6 in each row
·72	·94	1	6 × 6	2 „ $5\frac{1}{2}$ „
·94	1·14	$1\frac{1}{8}$	7 × 7	2 „ $5\frac{1}{2}$ „
1·14	1·20	$1\frac{1}{4}$	8 × 8	2 „ 5 „

* The thickness of the stringer angle is to be that of the sheerstrake or stringer plate, whichever is the less.

TABLE 20

(SEE CONTINUATION)

LOWER DECKS

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED)
			SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	
1	2	3	4	5	6	7	8
Feet	Feet	Inches	Square inches	Inches	Square inches	Inches	Inches
180	33	23	16	·28			·26
190	34	23¼	17	·28			·26
200	35	23½	18	·29			·26
210	36	23¾	19	·29			·26
220	37	24	21	·29			·26
230	38	24¼	23	·29			·26
240	39	24½	25	·30			·26
250	40	24¾	28	·30			·26
260	41	25	31	·30			·26
270	42	25¼	35	·30			·26
280	43	25½	38	·31			·26
290	44	25¾	42	·31			·26
300	45	26	46	·31			·26
310	46	26¼	50	·31			·26
320	47	26½	53	·32			·27
330	48	26¾	56	·32			·27
340	49	27	59	·32	53	·29	·27
350	50	27¼	62	·32	55	·29	·27
360	51	27½	64	·33	57	·30	·28
370	52	27¾	66	·33	59	·30	·28
380	53	28	68	·33	61	·30	·28
390	54	28¼	70	·33	63	·30	·28
400	55	28½	72	·34	65	·31	·29
410	56	28¾	75	·34	67	·31	·29
420	57	29	77	·34	69	·31	·29
430	58	29¼	80	·34	71	·31	·29
440	59	29½	82	·35	73	·32	·30
450	60	29¾	85	·35	75	·32	·30
460	61	30	88	·35	77	·32	·30
470	62	30¼	91	·36	79	·32	·30
480	63	30½	94	·36	82	·33	·30
490	64	30¾	97	·36	84	·33	·30
500	65	31	100	·37	87	·33	·31

For notes see page 113.

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED)
			SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED.)	SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	
1	2	3	4	5	6	7	8
Feet	Feet	Inches	Square inches	Inches	Square inches	Inches	Inches
510	66	$31\frac{1}{4}$	104	·37	90	·34	·31
520	67	$31\frac{1}{2}$	107	·38	93	·34	·31
530	68	$31\frac{3}{4}$	110	·38	96	·34	·31
540	69	32	113	·39	99	·35	·31
550	70	$32\frac{1}{4}$	117	·39	102	·35	·31
560	71	$32\frac{1}{2}$	120	·40	105	·36	·32
570	72	$32\frac{3}{4}$	123	·40	107	·36	·32
580	73	33	126	·41	110	·37	·32
590	74	$33\frac{1}{4}$	129	·41	112	·37	·32
600	75	$33\frac{1}{2}$	132	·42	115	·38	·32
610	76	$33\frac{3}{4}$	135	·42	118	·38	·32
620	77	34	139	·43	121	·39	·33
630	78	$34\frac{1}{4}$	142	·43	124	·39	·33
640	79	$34\frac{1}{2}$	145	·44	128	·40	·33
650	80	$34\frac{3}{4}$	148	·44	132	·40	·33

NOTES.—TABLE 20

1. Sectional area.—The Table area of lower decks (cols. 4 and 6) is for one side of the ship outside the line of hatchways or other openings and inside the line of notches for 'tween deck frames; it includes overlapped seams, if fitted.

2. Corrections.

For breadth.

If B differs from B_b (col. 2) the area is to be modified in direct proportion.

For beam spacing.

If the spacing of beams fitted at every frame, or of longitudinals, differs from that in col. 3 the minimum thickness of deck plating (cols. 5 and 7) is to be modified at the rate of ·01 inch for every 2 inches of difference.

3. Stringer plates and angles.—The thickness of stringer plates may be the same as that of the deck plating. Angles connecting the deck to shell plating are to have the same thickness as the stringer or deck plating to which they are attached.

4. Sheathed decks.—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 5, 7 and 8 may be reduced by 10 per cent.

5. Decks with stringer and tie plates.— Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

The width of stringer plates from shell to inner edge, for ·4L amidships, is not to be less than 38 inches and 46 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion

The thickness of the stringer and tie plates throughout is not to be less than given in col. 5.

TABLE 21
(SEE CONTINUATION)

SHORT SUPERSTRUCTURES

LENGTH L	SIDE PLATING		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE
1	2	3	4	5	6	7	8	9	10	11
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	·22	·22	12	5	·22	·22	·22	·24	·24	·24
110	·22	·22	13	5	·22	·22	·22	·24	·24	·24
120	·22	·22	14	5	·22	·22	·22	·24	·24	·24
130	·22	·22	15	5	·22	·22	·22	·24	·24	·24
140	·23	·23	16	5	·23	·23	·23	·24	·24	·24
150	·23	·24	17	5	·23	·24	·24	·24	·24	·24
160	·24	·25	18	6	·24	·25	·25	·25	·25	·25
170	·24	·25	19	6	·24	·25	·25	·25	·25	·25
180	·25	·26	20	6	·25	·26	·26	·25	·25	·25
190	·25	·27	21	6	·25	·27	·27	·25	·25	·25
200	·26	·28	22	7	·26	·28	·28	·26	·26	·26
210	·26	·28	23	7	·26	·28	·28	·26	·26	·26
220	·27	·29	24	7	·27	·29	·29	·26	·26	·26
230	·27	·29	25	7	·27	·29	·29	·26	·26	·26
240	·28	·30	26	8	·28	·30	·30	·26	·27	·27
250	·28	·30	26	8	·28	·30	·30	·26	·27	·27
260	·29	·31	27	8	·29	·31	·31	·26	·27	·27
270	·29	·32	28	8	·29	·32	·32	·26	·27	·27
280	·30	·33	29	8	·30	·33		·27	·28	·28
290	·30	·33	29	8	·30	·33		·27	·28	·28
300	·31	·34	30	8	·31	·34		·27	·28	·28
310	·31	·35	31	8	·31	·35		·27	·28	·28
320	·32	·36	32	9	·32	·36		·27	·29	·29
330	·32	·36	32	9	·32	·36		·27	·29	·29
340	·33	·37	33	9	·33	·37		·28	·29	·29
350	·33	·37	33	9	·33	·37		·28	·29	·29
360	·34	·38	34	9	·34	·38		·28	·30	·30
370	·34	·38	34	9	·34	·38		·28	·30	·30
380	·35	·39	35	9	·35	·39		·28	·30	·30
390	·35	·39	35	9	·35	·39		·28	·30	·30
400	·36	·40	36	10	·36			·28	·31	·31
410	·36	·40	36	10	·36			·28	·31	·31
420	·37	·41	37	10	·37			·29	·31	·31
430	·37	·41	37	10	·37			·29	·31	·31
440	·38	·42	38	10	·38			·29	·32	·32
450	·38	·42	38	10	·38			·29	·32	·32
460	·39	·43	39	10	·39			·29	·32	·32
470	·39	·43	39	10	·39			·29	·32	·32
480	·40	·44	40	11	·40			·30	·33	·33
490	·40	·44	40	11	·40			·30	·33	·33
500	·41	·45	41	11	·41			·30	·33	·33

PLATED DECK REQUIRED

PLATED DECK REQUIRED

For notes see page 115

LENGTH L	SIDE PLATING		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE
1	2	3	4	5	6	7	8	9	10	11
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
510	·41	·45	41	11	·41			·30	·33	·33
520	·42	·46	42	11	·42			·30	·34	·34
530	·42	·46	42	11	·42			·30	·34	·34
540	·43	·47	43	11	·43			·31	·34	·34
550	·43	·47	43	11	·43			·31	·34	·34
560	·44	·48	44	12	·44			·31	·35	·35
570	·44	·48	44	12	·44			·31	·35	·35
580	·45	·49	45	12	·45			·31	·35	·35
590	·45	·49	45	12	·45			·31	·35	·35
600	·46	·50	46	12	·46			·32	·36	·36
610	·46	·50	46	12	·46			·32	·36	·36
620	·47	·51	47	12	·47			·32	·36	·36
630	·47	·51	47	12	·47			·32	·36	·36
640	·48	·52	48	12	·48			·32	·37	·37
650	·48	·52	48	12	·48			·32	·37	·37

PLATED DECK REQUIRED

NOTES.—TABLE 21

1. Sheathed decks.—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 9, 10 and 11 may be reduced by 10 per cent.

2. Allowance for height of platform.—If the draught desired is not greater than ·7D (D being measured to the uppermost continuous deck) all thicknesses given in the Table may be reduced by 10 per cent.

3. Stringer angles.—Angles connecting the deck to shell plating are to have the same thickness as required for plated decks, cols. 9, 10 and 11.

TABLE 22 END BULKHEADS OF SUPERSTRUCTURES

Stiffeners spaced 30 inches apart

BULKHEADS AT THE FORE END OF BRIDGES, OF UNPROTECTED POOPS THE LENGTH OF WHICH IS ·4L OR MORE AND OF ALL POOPS PROTECTING MACHINERY OPENINGS

LENGTH L	BULB ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Feet	Inches ^{3} *Modulus—Inches*		Inches	Inches
Under 160	$5\frac{1}{2} \times 3 \times \cdot34$ *5·60*	3	$\frac{5}{8}$	·30
160	$6 \times 3 \times \cdot35$ *6·95*	3	$\frac{5}{8}$	·30
200	$6 \times 3 \times \cdot45$ *8·35*	4	$\frac{5}{8}$	·30
240	$7 \times 3 \times \cdot37$ *10·10*	4	$\frac{5}{8}$	·33
280	$7 \times 3 \times \cdot48$ *12·05*	4	$\frac{3}{4}$	·36
320	$8 \times 3 \times \cdot40$ *14·30*	5	$\frac{3}{4}$	·39
360	$8 \times 3 \times \cdot49$ *16·35*	5	$\frac{3}{4}$	·42
400	$9 \times 3\frac{1}{2} \times \cdot41$ *19·15*	5	$\frac{3}{4}$	·44
440	$9 \times 3\frac{1}{2} \times \cdot51$ *21·90*	5	$\frac{3}{4}$	·44
480	$10 \times 3\frac{1}{2} \times \cdot42$ *24·80*	5	$\frac{3}{4}$	·44
520	$10 \times 3\frac{1}{2} \times \cdot53$ *28·45*	6	$\frac{3}{4}$	·44
560	$11 \times 3\frac{1}{2} \times \cdot45$ *31·95*	6	$\frac{3}{4}$	·44

BULKHEADS OF POOPS PARTIALLY PROTECTED OR LESS IN LENGTH THAN ·4L AND NOT PROTECTING MACHINERY OPENINGS

LENGTH L	ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Feet	Inches ^{3} *Modulus—Inches*		Inches	Inches
Under 150	$3 \times 2\frac{1}{2} \times \cdot30$ *1·00*	2	$\frac{5}{8}$	·24
150	$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot32$ *1·40*	2	$\frac{5}{8}$	·24
200	$4 \times 3 \times \cdot34$ *1·90*	2	$\frac{5}{8}$	·26
250	$4 \times 3 \times \cdot46$ *2·50*	2	$\frac{5}{8}$	·29
300	$5 \times 3 \times \cdot38$ *3·15*	3	$\frac{5}{8}$	·32
350	$6 \times 3 \times \cdot35$ *4·20*	3	$\frac{5}{8}$	·35
400	$6 \times 3 \times \cdot44$ *5·20*	3	$\frac{3}{4}$	·38
450	$7 \times 3\frac{1}{2} \times \cdot40$ *6·35*	3	$\frac{3}{4}$	·38
500	$7 \times 3\frac{1}{2} \times \cdot48$ *7·55*	4	$\frac{3}{4}$	·38
550	$7 \times 3\frac{1}{2} \times \cdot50$ *7·80*	4	$\frac{3}{4}$	·38

BULKHEADS AT AFTER ENDS OF BRIDGES AND FORECASTLES

LENGTH L	ANGLE STIFFENERS	PLATING
Feet	Inches ^{3} *Modulus—Inches*	Inches
Under 150	$2\frac{1}{2} \times 2\frac{1}{2} \times \cdot26$ *·60*	·20
150	$3 \times 2\frac{1}{2} \times \cdot28$ *·90*	·20
250	$3\frac{1}{2} \times 3 \times \cdot30$ *1·30*	·24
350	$4 \times 3 \times \cdot32$ *1·80*	·28
400 and above	$4 \times 3 \times \cdot40$ *2·20*	·30

Stiffeners to overlap, and be riveted to boundary angles

Section moduli above are given to nearest ·05

NOTES.—TABLE 22

1. **Correction for spacing of stiffeners.**—If the spacing of stiffeners differs from 30 inches, modulus of stiffeners is to be modified in direct proportion.

If the spacing of the stiffeners is greater than 30 inches, the thickness of plating is to be increased at the rate of ·01 inch for every 2 inches increase in spacing.

2. **Allowance for height of platform.**—When the draught d does not exceed ·7D, D being measured to the uppermost continuous deck, the scantlings given in the Table may be modified as follows :—

THICKNESS OF PLATING.

Where L = 200 feet or less, thickness may be 90 per cent of Table thickness.

Where L = 400 feet of above, thickness may be 85 per cent of Table thickness.

MODULUS OF STIFFENERS.

Where L = 200 feet or less, modulus may be 75 per cent of Table modulus.

Where L = 400 feet or above, modulus may be 70 per cent of Table modulus.

For intermediate lengths the percentage may be obtained by interpolation.

3. Bulkheads at the fore ends of bridges which do not cover deck openings are to have plating as required by the Table, but the modulus of the stiffeners may be reduced by 10 per cent.

4. Particulars of sections and moduli are given in Table 56.

DECKHOUSES

LOWER TIER

Stiffeners spaced 30 inches apart

LENGTH L	FRONTS		SIDES		CORRECTION PER FOOT DIFFERENCE IN DRAUGHT (See NOTE 1)	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet	Inches *Modulus—Inches³*	Inches	Inches *Modulus—Inches³*	Inches	Per cent	Per cent
200	4 × 3 × ·41 *2·25*	·26	3½ × 3 × ·32 *1·40*	·25	10	6
300	5 × 3 × ·35 *2·95*	·28	4 × 3 × ·30 *1·65*	·26	25	8
400	5 × 3 × ·46 *3·80*	·30	4 × 3 × ·36 *2·00*	·28	40	10
500	6 × 3 × ·45 *5·30*	·32	5 × 3 × ·32 *2·65*	·30	50	11
600	6 × 3 × ·60 *6·95*	·34	5½ × 3 × ·34 *3·46*	·32	50	12

ANGLES

UPPER TIER

Stiffeners spaced 30 inches apart

LENGTH L	FRONTS		SIDES		CORRECTION PER FOOT DIFFERENCE IN DRAUGHT (See NOTE 1)	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet	Inches *Modulus—Inches³*	Inches	Inches *Modulus—Inches³*	Inches	Per cent	Per cent
200	3 × 2½ × ·26 *·85*	·24	2½ × 2½ × ·30 *·70*	·23	10	5
300	3 × 2½ × ·32 *1·10*	·24	3 × 2½ × ·28 *·90*	·23	15	6
400	3½ × 3 × ·32 *1·40*	·26	3 × 3 × ·36 *1·20*	·24	20	7
500	4 × 3 × ·34 *1·90*	·28	3½ × 3 × ·36 *1·55*	·26	25	8
600	4 × 3 × ·46 *2·50*	·30	4 × 3 × ·36 *2·00*	·28	30	9

ANGLES

For notes see page 119

TABLE 23

(SEE CONTINUATION)

BEAMS WITH PLATED DECK

Spaced 30 inches apart

LENGTH L	SPAN FEET					
	10		15		20	
Feet	INCHES Modulus—Inches³					
200	ANGLES	$3 \times 2\frac{1}{2} \times \cdot 28$ *·90*	ANGLES	$4 \times 3 \times \cdot 36$ *2·00*	ANGLES	$5 \times 3 \times \cdot 42$ *3·50*
300		$3\frac{1}{2} \times 3 \times \cdot 32$ *1·35*		$5 \times 3 \times \cdot 30$ *2·55*		$6 \times 3 \times \cdot 34$ *4·10*
400		$4 \times 3 \times \cdot 32$ *1·75*		$5 \times 3 \times \cdot 37$ *3·10*	BULB ANGLES	$5 \times 3 \times \cdot 40$ *5·15*
500		$4\frac{1}{2} \times 3 \times \cdot 30$ *2·05*		$5 \times 3 \times \cdot 44$ *3·65*		$5 \times 3 \times \cdot 45$ *5·65*
600		$4\frac{1}{2} \times 3 \times \cdot 38$ *2·60*		$6 \times 3 \times \cdot 36$ *4·30*		$6 \times 3 \times \cdot 30$ *6·25*

DECK PLATING

ABOVE DECKHOUSES

LENGTH L	AREA OF DECK ABOVE LONG HOUSES — PERCENTAGE OF AREA OF STRENGTH DECK ASSUMING TWO DECKS FITTED	MINIMUM THICKNESS OF DECK PLATING (*See* NOTE 9)	
		UNSHEATHED	SHEATHED
1	2	3	4
Feet	Per cent	Inches	Inches
200	60	·24	·20
300	50	·25	·22
400	40	·26	·23
500	35	·28	·24
550	30	·30	·25

For notes see page 119

TABLE 23.—NOTES

1. **Draught.**—The Table is directly applicable when the ratio d/D = ·70, D being measured to the deck upon which the lowest tier of deckhouses is situated.

If the draught is $\frac{\text{greater}}{\text{less}}$ than that corresponding to the above ratio the modulus of the stiffeners and the thickness of the plating of the deckhouse fronts and sides are to be $\frac{\text{increased}}{\text{reduced}}$ by the percentages given in this Table, subject to a maximum increase of 100 per cent and a maximum reduction of 20 per cent in modulus and subject to a maximum reduction of 10 per cent in the thickness of the plating.

2. **Spacing of stiffeners.**—If the spacing of the stiffeners differs from 30 inches, the modulus of the stiffeners is to be modified in direct proportion. The thickness of the plating is to be increased at the rate of ·01 inch for every 3 inches increase in spacing.

3. **Single tier deckhouses.**—For deckhouses not having an upper tier of houses the modulus of stiffeners of the sides and aft end may, after correction for draught, be reduced by 15 per cent except where d/D exceeds ·70.

4. **Breadth of deckhouse fronts.**—The Table is directly applicable, subject to the above corrections, to deckhouse fronts which are ·75B or more in breadth.

When the breadth of a partially protected house front is ·25B or less, the scantlings may be as required for sides; when the breadth is intermediate between these limits the scantlings may be obtained by interpolation.

5. **Flush deck ships, and those with forecastles, or forecastles and poops, having minimum freeboards.**—The modulus of stiffeners at the fronts of houses in these ships is, after correction, to be increased by 100 per cent, and two webs are to be arranged.

The corrected thickness of the front plating is to be increased 5 per cent.

6. **After ends of houses.**—The modulus of the stiffeners is to be 70 per cent of that of the side stiffeners and the thickness of the plating is to be 90 per cent of that of the side plating based on 30 inch spacing. Unprotected deckhouses at after ends of ships will be specially considered.

7. **End connections of stiffeners.**—Stiffeners at fronts of deckhouses are to be lugged except at the upper tier when L is less than 500 ft. Stiffeners at sides of lower tier are to be bracketed if there are two tiers, and lugged if there is only one tier; those at upper tiers are to be lugged when L exceeds 500 ft. Stiffeners at aft ends of deckhouses may be unattached. If stiffeners are welded to the deck, brackets may be omitted, provided the section modulus of the stiffeners is increased by 20 per cent.

8. **Beams.**—The Table is directly applicable to the beams of a lower deckhouse having superimposed houses. If there are no superimposed houses the modulus of the beam may be reduced by 20 per cent.

The modulus of the beams of the upper tier may be 20 per cent less than required by the Table and if there is a third tier the beams of that tier may be 40 per cent less than required by the Table.

If the beam spacing differs from 30 inches the modulus of the beams is to be modified in direct proportion.

9. **Deck plating above houses.**—Where the length of a deckhouse exceeds ·15L, deck plating of the sectional area derived from the Table is to be fitted at the top of the house.

The two decks referred to in col. 2 are the decks of the main hull as used in Table 18.

If there are two tiers of houses the sectional area of the top of each may be 80 per cent of the area derived from the Table, or alternatively the top of the upper tier may be 75 per cent, and of the lower tier 100 per cent of that area.

The minimum thicknesses of plating given in cols. 3 and 4 apply to decks outside deckhouses and outside line of openings; within the line of openings the thicknesses may be reduced by 10 per cent. Inside deckhouses the thicknesses may be reduced by a further 10 per cent.

The thickness of unsheathed plating (col. 3) is to be increased by ·01 inch for each 3 inch increase of spacing above 36 inches.

10. Where the height of deckhouses exceeds 9 feet the scantlings will be specially considered.

11. **Exposed machinery casings.**—The thickness of the plating and the modulus of the stiffeners are to be 20 per cent greater than those for deckhouses in the same position.

12. Particulars of sections and moduli are given in Table 56.

BREADTH B	BEAM SPACING	CORRECTION FACTOR K		UNSUPPORTED SPAN FEET 6	8	10	12	14	16
Feet	Inches			INCHES *Modulus—Inches*^{3}					
24	21	1·20	ANGLES	$3 \times 2\frac{1}{2} \times \cdot30$ *1·00*	$3 \times 2\frac{1}{2} \times \cdot38$ *1·25*	$3\frac{1}{2} \times 3 \times \cdot34$ *1·45*	$3\frac{1}{2} \times 3 \times \cdot39$ *1·70*		
28	22	1·20	ANGLES	$3 \times 2\frac{1}{2} \times \cdot34$ *1·15*	$3\frac{1}{2} \times 3 \times \cdot32$ *1·40*	$3\frac{1}{2} \times 3 \times \cdot37$ *1·60*	$3\frac{1}{2} \times 3 \times \cdot44$ *1·90*	$4 \times 3 \times \cdot42$ *2·30*	
32	23	1·20	ANGLES	$3\frac{1}{2} \times 3 \times \cdot32$ *1·40*	$3\frac{1}{2} \times 3 \times \cdot38$ *1·65*	$3\frac{1}{2} \times 3 \times \cdot44$ *1·90*	$4 \times 3 \times \cdot39$ *2·15*	$4 \times 3 \times \cdot48$ *2·65*	$5 \times 3 \times \cdot37$ *3·10*
36	24	1·20	ANGLES		$4 \times 3 \times \cdot38$ *2·10*	$4 \times 3 \times \cdot44$ *2·40*	$5 \times 3 \times \cdot32$ *2·70*	$5 \times 3 \times \cdot41$ *3·40*	$6 \times 3 \times \cdot33$ *4·00*
40	25	1·20	ANGLES		$5 \times 3 \times \cdot34$ *2·85*	$5 \times 3 \times \cdot39$ *3·25*	$5 \times 3 \times \cdot44$ 3·65	$6 \times 3 \times \cdot37$ *4·40*	$5\frac{1}{2} \times 3 \times \cdot32$ 5·40
44	26	1·20	ANGLES			$6 \times 3 \times \cdot38$ *4·55*	$5 \times 3 \times \cdot39$ *5·05*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*
48	27	1·20	BULB ANGLES			$5\frac{1}{2} \times 3 \times \cdot38$ *6·05*	$6 \times 3\frac{1}{2} \times \cdot34$ *6·85*	$6 \times 3\frac{1}{2} \times \cdot41$ *7·80*	$6 \times 3\frac{1}{2} \times \cdot48$ *8·80*
52	28	1·20	BULB ANGLES			$6 \times 3\frac{1}{2} \times \cdot41$ *7·80*	$6 \times 3\frac{1}{2} \times \cdot48$ *8·80*	$7 \times 3\frac{1}{2} \times \cdot35$ 9·80	$7 \times 3\frac{1}{2} \times \cdot42$ *10·95*
56	29	1·16	BULB ANGLES				$7 \times 3\frac{1}{2} \times \cdot41$ *10·80*	$7 \times 3\frac{1}{2} \times \cdot47$ *11·85*	*13·05*
60	30	1·12	BULB ANGLES				$7 \times 3\frac{1}{2} \times \cdot51$ *12·65*	$8 \times 3\frac{1}{2} \times \cdot38$ *13·85*	$8 \times 3\frac{1}{2} \times \cdot43$ *15·05*
64	31	1·08	BULB ANGLES				$8 \times 3\frac{1}{2} \times \cdot41$ *14·60*	$8 \times 3\frac{1}{2} \times \cdot46$ *15·75*	$8 \times 3\frac{1}{2} \times \cdot52$ *17·15*
68	32	1·04	BULB ANGLES				$8 \times 3\frac{1}{2} \times \cdot48$ *16·20*	$8 \times 3\frac{1}{2} \times \cdot53$ *17·40*	$9 \times 3\frac{1}{2} \times \cdot40$ *18·90*
72	33	1·00	BULB ANGLES				$8 \times 3\frac{1}{2} \times \cdot53$ *17·40*	$9 \times 3\frac{1}{2} \times \cdot40$ *18·90*	$9 \times 3\frac{1}{2} \times \cdot46$ *20·50*
76	34	1·00	BULB ANGLES					$9 \times 3\frac{1}{2} \times \cdot44$ *19·90*	$9 \times 3\frac{1}{2} \times \cdot50$ *21·60*
80	35	1·00	BULB ANGLES				$9 \times 3\frac{1}{2} \times \cdot41$ *19·15*	$9 \times 3\frac{1}{2} \times \cdot47$ *20·80*	$9 \times 3\frac{1}{2} \times \cdot54$ *22·70*

Section moduli above a

NOTES.—TABLE 24

1. **Application to various decks.**—(*a*) The modulus given in the Table applies to weather deck beams in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following :—

(1) Single deck ships – – – (*see* (*d*))
(2) Short bridges and poops – – (*see* (*f*))
(3) Forecastle decks – – – (*see* (*g*))
(4) The forward ·12L of weather decks– (*see* (*g*))

(*b*) When d/D is ·85 or greater the modulus for weather deck beams (except as qualified by (*d*) to (*g*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D = ·7 and the Table factor K for d/D = ·85.

(*d*) **Single deck ships.** The modulus is to be obtained in accordance with the above notes and increased by 20 per cent.

(*e*) **Bridges forming an effective superstructure** as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*f*) **Short bridges and poops.** The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

UNSUPPORTED SPAN FEET 18	20	22	24	26		CORRECTION FACTOR K	BEAM SPACING	BREADTH B
INCHES *Modulus—Inches*³							Inches	Feet
					ANGLES	1·20	21	24
						1·20	22	28
						1·20	23	32
6 × 3 × ·41 *4·90*						1·20	24	36
5½×3 × ·41 *6·40*	6 × 3 × ·40 *7·65*					1·20	25	40
6 × 3 × ·44 *8·20*	7 × 3 × ·35 *9·80*	7 × 3 × ·46 *11·65*				1·20	26	44
7 × 3½×·37 *10·15*	7 × 3½×·46 *11·65*	8 × 3½×·37 *13·65*	8 × 3½×·46 *15·75*			1·20	27	48
7 × 3½×·49 *12·25*	8 × 3½×·38 *13·85*	8 × 3½×·46 *15·75*	8 × 3½×·55 *17·85*	9 × 3½×·45 *20·20*		1·20	28	52
8 × 3½×·40 *14·35*	8 × 3½×·47 *16·00*	8 × 3½×·56 *18·05*	9 × 3½×·45 *20·20*	9 × 3½×·53 *22·45*	BULB ANGLES	1·16	29	56
8 × 3½×·49 *16·45*	8 × 3½×·56 *18·05*	9 × 3½×·45 *20·20*	9 × 3½×·54 *22·70*	10 × 3½×·44 *25·45*		1·12	30	60
9 × 3½×·39 *18·65*	9 × 3½×·45 *20·20*	9 × 3½×·54 *22·70*	10 × 3½×·43 *25·15*	10 × 3½×·52 *28·10*		1·08	31	64
9 × 3½×·46 20·50	9 × 3½×·53 *22·45*	10 × 3½×·42 *24·80*	10 × 3½×·51 *27·75*	*31·00*		1·04	32	68
9 × 3½×·52 *22·20*	10 × 3½×·41 *24·50*	10 × 3½×·49 *27·10*	10 × 3½×·58 *30·10*	11 × 3½×·48 *33·05*		1·00	33	72
9 × 3½×·57 *23·60*	10 × 3½×·45 *25·80*	10 × 3½×·53 *28·45*	11 × 3½×·44 *31·55*	11 × 3½×·52 *34·55*		1·00	34	76
10 × 3½×·41 *24·50*	10 × 3½×·48 *26·80*	10 × 3½×·57 *29·80*	11 × 3½×·47 *32·70*	11 × 3½×·55 *35·80*		1·00	35	80

iven to nearest ·05

NOTES.—TABLE 24 (*concluded*).

(*g*) **Forecastles and weather decks.** For the forward ·075L the Table Modulus is to be multiplied by the factor 1·2K irrespective of draught. Between ·075L and ·12L from forward, the Table Modulus is to be multiplied by the factor K, irrespective of draught.

2. **Span** for use in the Table is to be measured in feet from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. **Corrections to modulus of beams.**

FOR BEAM SPACING.

If the spacing at any point differs from that given in the Table the modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of beams derived from Table 25 and note 3 to that Table.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 25

BEAMS AT CARGO AN

BREADTH B	BEAM SPACING	CORRECTION FACTOR C		UNSUPPORTED SPAN FEET 6	8	10	12	14	16
Feet	Inches			INCHES Modulus—Inches³					
24	21	·50	ANGLES	3 × 2½×·34 *1·15*	3½×3 × ·43 *1·85*	4 × 3 × ·48 *2·65*	5 × 3 × ·41 *3·40*		
28	22	·50	ANGLES	3 × 2½×·34 *1·15*	3½×3 × ·43 *1·85*	*2·80*	5 × 3 × ·45 *3·75*	6 × 3 × ·39 *4·65*	
32	23	·50	ANGLES		4 × 3 × ·36 *2·00*	5 × 3 × ·37 *3·10*	6 × 3 × ·35 *4·20*	5½×3 × ·30 *5·15*	5½×3 × ·40 *6·25*
36	24	·50	ANGLES		4 × 3 × ·40 *2·20*	5 × 3 × ·41 *3·40*	6 × 3 × ·39 *4·65*	5½×3 × ·38 *6·05*	6 × 3 × ·39 *7·50*
40	25	·50	ANGLES		4 × 3 × ·43 *2·35*	5 × 3 × ·44 *3·65*	5½×3 × ·31 *5·30*	5½×3 × ·46 *6·95*	6 × 3 × ·49 *8·90*
44	26	·55	ANGLES		5 × 3 × ·30 *2·55*	6 × 3 × ·34 *4·10*	5½× 3 ×·37 *5·95*	6 × 3 × ·42 *7·90*	7 × 3 × ·38 *10·25*
48	27	·60	ANGLES		5 × 3½×·32 *2·70*	6 × 3½×·38 *4·50*	6 × 3½×·31 *6·50*	6 × 3½×·48 *8·80*	7 × 3½×·45 *11·50*
52	28	·65	ANGLES		5 × 3½×·34 *2·85*	6 × 3½×·42 *4·95*	6 × 3½×·37 *7·25*	7 × 3½×·36 *9·95*	7 × 3½×·52 *12·80*
56	29	·70	BULB ANGLES				6 × 3½×·43 *8·10*	7 × 3½×·42 *10·95*	8 × 3½×·39 *14·10*
60	30	·75	BULB ANGLES				6 × 3½×·50 *9·05*	7 × 3½×·49 *12·25*	8 × 3½×·44 *15·25*
64	31	·80	BULB ANGLES				7 × 3½×·39 *10·45*	8 × 3½×·37 *13·65*	8 × 3½×·50 *16·70*
68	32	·85	BULB ANGLES				7 × 3½×·48 *12·05*	8 × 3½×·43 *15·05*	8 × 3½×·56 *18·05*
72	33	·90	BULB ANGLES				8 × 3½×·39 *14·10*	8 × 3½×·50 *16·70*	9 × 3½×·43 *19·65*
76	34	·90	BULB ANGLES					9 × 3½×·39 *18·65*	9 × 3½×·48 *21·05*
80	35	·90	BULB ANGLES					9 × 3½×·47 *20·80*	9 × 3½×·5 *22·70*

Section moduli above

NOTES.—TABLE 25

1. Application to various decks.—(*a*) Cargo decks. The modulus of the beams is to be determined directly from the Table and corrected as required below.

(*b*) Accommodation decks. The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. Span for use in the Table is to be measured from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. Corrections to modulus of beams.

FOR BEAM SPACING.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

UNSUPPORTED SPAN FEET						CORRECTION FACTOR C	BEAM SPACING	BREADTH B
18	20	22	24	26				
INCHES *Modulus—Inches³*							Inches	Feet
					ANGLES	·50	21	24
						·50	22	28
						·50	23	32
6 × 3 × ·51 *9·15*						·50	24	36
7 × 3 × ·43 *11·15*	7 × 3 × ·56 *13·50*					·50	25	40
7 × 3 × ·53 *13·00*	8 × 3 × ·47 *15·90*	9 × 3½ × ·40 *18·90*				·55	26	44
8 × 3½ × ·41 *14·60*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·49 *21·35*	10 × 3½ × ·43 *25·15*			·60	27	48
8 × 3½ × ·48 *16·20*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·59 *30·45*	BULB ANGLES	·65	28	52
8 × 3½ × ·54 *17·60*	9 × 3½ × ·47 *20·80*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·52 *28·10*	11 × 3½ × ·45 *31·95*		·70	29	56
9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·48 *33·05*		·75	30	60
9 × 3½ × ·44 *19·90*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·52 *34·55*		·80	31	64
9 × 3½ × ·48 *21·05*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·51 *27·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·55 *35·80*		·85	32	68
9 × 3½ × ·53 *22·45*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·58 *37·00*		·90	33	72
9 × 3½ × ·57 *23·60*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·61 *38·20*		·90	34	76
10 × 3½ × ·42 *24·80*	10 × 3½ × ·51 *27·75*	*31·15*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·63 *39·00*		·90	35	80

given to nearest ·05

NOTES.—TABLE 25 (*concluded*)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 8 feet 6 inches, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, modulus is to be increased by 30, 60 and 90 per cent for one, two and three tiers respectively. For accommodation decks these percentages are to be 50, 100 and 150 respectively.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted, the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 26 LONGITUDINALS AT WEATHER DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR K	UNSUPPORTED SPAN FEET				
			6	8	10	12	
Feet	Inches		INCHES *Modulus—Inches*³				
160	27½	1·20	5 × 3 × ·30 *2·55*	5 × 3 × ·39 *3·25*			ANGLES
180	28	1·20	5 × 3 × ·33 *2·80*	5 × 3 × ·41 *3·40*			
200	28½	1·20	5 × 3 × ·36 *3·00*	5 × 3 × ·44 *3·65*			
220	29	1·20	5 × 3 × ·39 *3·25*	5 × 3 × ·46 *3·80*			
240	29½	1·20	5 × 3 × ·41 *3·40*	5 × 3 × ·48 *3·95*			
260	30	1·20	5 × 3 × ·44 *3·65*	6 × 3 × ·35 *4·20*			
280	30½	1·20	5 × 3 × ·46 *3·80*	6 × 3 × ·37 *4·40*	6 × 3 × ·42 *5·00*		
300	31	1·20	5 × 3 × ·48 *3·95*	6 × 3 × ·39 *4·65*	5 × 3 × ·41 *5·25*	5½ × 3 × ·37 *5·95*	ANGLES
320	31½	1·20	6 × 3 × ·35 *4·20*	5½ × 3 × ·30 *5·15*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	
340	32	1·20	6 × 3 × ·37 *4·40*	5½ × 3 × ·34 *5·60*	6 × 3 × ·34 *6·80*	6 × 3 × ·43 *8·05*	
360	32½	1·20	6 × 3½ × ·39 *4·65*	6 × 3½ × ·28 *6·10*	6 × 3½ × ·40 *7·65*	6 × 3½ × ·50 *9·05*	
380	33	1·18	6 × 3½ × ·41 *4·85*	6 × 3½ × ·32 *6·60*	6 × 3½ × ·45 *8·35*	7 × 3½ × ·38 *10·25*	
400	33½	1·16	6 × 3½ × ·43 *5·05*	6 × 3½ × ·36 *7·10*	*9·20*	7 × 3½ × ·44 *11·30*	
420	34	1·14		6 × 3½ × ·40 *7·65*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·50 *12·45*	BULB ANGLES
440	34½	1·12		6 × 3½ × ·44 *8·20*	7 × 3½ × ·41 *10·80*	8 × 3½ × ·36 *13·45*	
460	35	1·10		6 × 3½ × ·47 *8·65*	7 × 3½ × ·46 *11·65*	8 × 3½ × ·41 *14·60*	
480	35½	1·08		*9·20*	7 × 3½ × ·50 *12·45*	8 × 3½ × ·46 *15·75*	
500	36	1·06		7 × 3½ × ·34 *9·65*	*13·00*	8 × 3½ × ·50 *16·70*	

BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 26

1. Application to various decks.—(*a*) The modulus given in the Table applies to weather deck longitudinals outside the line of deck openings, in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following :—

Short bridges ... ... (*see* (*e*))

(*b*) When d/D is ·85 or greater the modulus for weather deck longitudinals (except as qualified by (*d*) to (*i*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D=·7 and the Table factor K for d/D=·85.

(*d*) Bridges forming an effective superstructure as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*e*) Short bridges. The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*f*) Outside the line of openings the modulus derived as above is to be maintained for ·4L amidships and may be gradually reduced to 70 per cent of the midship value at ·1L from the after end and to 85 per cent at ·12L from the fore end.

(*g*) Within the line of openings abaft ·12L from forward the modulus may be 70 per cent of that required outside the line of openings amidships.

(*h*) For the forward ·075L of forecastles and weather decks, the Table Modulus is to be multiplied by the factor 1·2K irrespective of draught. Between ·075L and ·12L from forward the Table Modulus is to be multiplied by the factor K irrespective of draught.

2. Span for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. Corrections to modulus of longitudinals.

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of longitudinals derived from Table 27 and note 3 to that Table.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 27

LONGITUDINALS AT CARGO AND ACCOMMODATION DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR C	UNSUPPORTED SPAN FEET				
			6	8	10	12	
Feet	Inches		INCHES ^{3} *Modulus—Inches*				
160	$27\frac{1}{2}$	·50	$3\frac{1}{2}\times3\times\cdot35$ *1·50*	$5\times3\times\cdot29$ *2·40*			ANGLES
180	28	·50	$4\times3\times\cdot29$ *1·60*	$5\times3\times\cdot30$ *2·55*			
200	$28\frac{1}{2}$	·50	$4\times3\times\cdot32$ *1·80*	$5\times3\times\cdot33$ *2·80*			
220	29	·50	$4\times3\times\cdot35$ *1·95*	$5\times3\times\cdot35$ *2·95*			
240	$29\frac{1}{2}$	·50	$4\times3\times\cdot39$ *2·15*	$5\times3\times\cdot38$ *3·15*			
260	30	·50	$4\times3\times\cdot44$ *2·40*	$5\times3\times\cdot41$ *3·40*			
280	$30\frac{1}{2}$	·50	$5\times3\times\cdot32$ *2·70*	$5\times3\times\cdot45$ *3·75*	$6\times3\times\cdot38$ *4·55*		
300	31	·55	$5\times3\times\cdot36$ *3·00*	$5\times3\times\cdot48$ *3·95*	$6\times3\times\cdot41$ *4·85*	$5\frac{1}{2}\times3\times\cdot37$ *5·95*	ANGLES
320	$31\frac{1}{2}$	·60	$5\times3\times\cdot40$ *3·30*	$6\times3\times\cdot36$ *4·30*	$5\times3\times\cdot42$ *5·35*	$5\frac{1}{2}\times3\times\cdot41$ *6·40*	
340	32	·62	$5\times3\times\cdot44$ *3·65*	$6\times3\times\cdot40$ *4·75*	$5\frac{1}{2}\times3\times\cdot36$ *5·80*	$6\times3\times\cdot35$ *6·95*	
360	$32\frac{1}{2}$	·65	$6\times3\times\cdot34$ *4·10*	$5\times3\times\cdot40$ *5·15*	$5\frac{1}{2}\times3\times\cdot40$ *6·25*	$6\times3\times\cdot38$ *7·35*	
380	33	·67	$6\times3\times\cdot37$ *4·40*	$5\frac{1}{2}\times3\times\cdot34$ *5·60*	$5\frac{1}{2}\times3\times\cdot44$ *6·70*	$6\times3\times\cdot42$ *7·90*	
400	$33\frac{1}{2}$	·70	$6\times3\frac{1}{2}\times\cdot40$ *4·70*	$5\frac{1}{2}\times3\times\cdot37$ *5·95*	$6\times3\frac{1}{2}\times\cdot36$ *7·10*	$6\times3\frac{1}{2}\times\cdot45$ *8·35*	
420	34	·72		$6\times3\frac{1}{2}\times\cdot30$ *6·35*	$6\times3\frac{1}{2}\times\cdot40$ *7·65*	$6\times3\frac{1}{2}\times\cdot49$ *8·95*	BULB ANGLES
440	$34\frac{1}{2}$	·75		$6\times3\frac{1}{2}\times\cdot34$ *6·85*	$6\times3\frac{1}{2}\times\cdot43$ *8·10*	*9·40*	
460	35	·77		$6\times3\frac{1}{2}\times\cdot37$ *7·25*	$6\times3\frac{1}{2}\times\cdot46$ *8·50*	$7\times3\frac{1}{2}\times\cdot36$ *9·95*	
480	$35\frac{1}{2}$	·80		$6\times3\frac{1}{2}\times\cdot40$ *7·65*	$6\times3\frac{1}{2}\times\cdot50$ *9·05*	$7\times3\frac{1}{2}\times\cdot39$ *10·45*	
500	36	·82		$6\times3\frac{1}{2}\times\cdot42$ *7·95*	*9·45*	$7\times3\frac{1}{2}\times\cdot42$ *10·95*	

Section moduli above are given to nearest ·05

TABLE 27
(CONCLUDED)

NOTES.—TABLE 27

1. Application to various decks.—(*a*) For all cargo decks the modulus of the deck longitudinals is to be determined directly from the Table and corrected as required below.

(*b*) Accommodation decks. The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. Span for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. Corrections to modulus of longitudinals.

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table modulus is to be modified in direct proportion.

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 8 feet 6 inches modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent for one, two and three tiers respectively. For accommodation decks these percentages are to be 50, 100 and 150 respectively.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 28

(*SEE CONTINUATION*)

BEAM KNEES AND END BRACKETS OF DECK LONGITUDINALS

DEPTH OF BEAM, FRAME, OR LONGITUDINAL	KNEES OR BRACKETS					CONNECTIONS				
	DEPTH FROM DECK	OVERLAP ON BEAM OR LONGITUDINAL	NOT FLANGED	FLANGED		BEAM KNEE		LONGITUDINAL BRACKET		DIAMETER OF RIVETS
			THICKNESS	THICKNESS	WIDTH	NUMBER OF RIVETS	AREA OF WELD	NUMBER OF RIVETS	AREA OF WELD	
1	2	3	4	5	6	7	8	9	10	11
Inches	Inches	Inches	Inches	Inches	Inches		Sq. inches		Sq. inches	Inches
5 and below	12½	9	·28			4	1·5	6	2·25	$\frac{5}{8}$
5½	14	10	·29			4	2·0	5	2·5	$\frac{3}{4}$
6	15	11	·30			4	2·0	6	3·0	$\frac{3}{4}$
7	17½	13	·33			4	2·0	7	3·5	$\frac{3}{4}$
8	20	14½	·36			5	2·5	8	4·0	$\frac{3}{4}$
9	22½	16	·39			5	3·5	8	5·5	$\frac{7}{8}$
10	25	18	·42	·36	2	6	4·0	9	6·25	$\frac{7}{8}$
11	27½	20	·45	·38	2¼	7	4·75			$\frac{7}{8}$
12	30	22	·48	·40	2½	8	5·5			$\frac{7}{8}$
13½	34	24½		·42	2¾	9	6·25			$\frac{7}{8}$
15	38	27		·44	3	10	7·0			$\frac{7}{8}$

For notes see pages 129 and 130

NOTES.—TABLE 28

1. Beam knees. The dimensions shown in cols. 2 to 6 and the riveting shown in cols. 7 and 11 apply to beam knees and, with the exceptions given in notes 2 to 5 below, are based on the depth of beams.

2. In single deck ships, and at the second deck in two deck ships if the hold frames terminate at that deck, the Table is to be used on the basis of the depth of frame or beam whichever is greater but the depth of the knee is not to be less than 14 inches. (*See* Table below for knees acting as butt straps to frames.)

3. At the third deck in three deck ships if the hold frames terminate at that deck, the Table is to be used on the basis of depth of beam except that the depth of the knee below the deck and the number of rivets in the vertical arm are not to be less than required by cols. 3 and 7 for the depth of the frame; the depth of the knee is not to be less than 14 inches. (*See* Table overleaf for knees acting as butt straps to frames.)

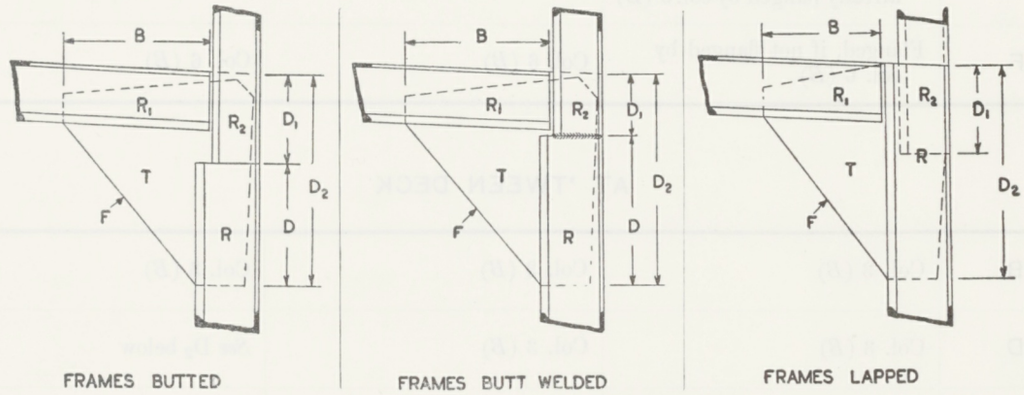
4. When the beam knee acts as a strap connecting an upper and a lower frame notes 1 to 3 are to be applied with the modifications shown in the Table overleaf.

5. In the panting region the knees at the lower deck are not to be less than required for the depth of frame or beam whichever is greater.

6. Brackets to deck longitudinals are to have dimensions not less than those given in cols. 2 and 3 but suitable for the number of rivets given in col. 9.

7. Area of weld is the product of the throat thickness and the length of the weld. The throat thickness is not to be less than 70 per cent of the leg length for Type 3 weld. (*See* Table 52 G.)

BEAM KNEES USED AS FRAME STRAPS



The letters (*B*) or (*F*) below denote whether the requirements are based on beam or frame : if both, the greater is to be used. (*F, T. Dk*) below denotes requirements based on depth of 'tween deck frames.

AT SECOND DECK OF TWO DECK SHIPS

B	Col. 3 (*B* or *F*)	Col. 3 (*B* or *F*)	Col. 3 (*B* or *F*)
D	Col. 3 (*F*)	Col. 3 (*F*)	*See* D_2 below
D_1	Col. 3 (*F, T. Dk*)	Enough for rivets	Col. 3 (*F, T. Dk*)
D_2	Not less than col. 2 (*B* or *F*)	Not less than col. 2 (*B* or *F*)	Col. 2 (*B* or *F*)
R	Col. 7 (*F*)	Col. 7 (*B* or *F*) including R_2	Col. 7 (*B* or *F*) including R_2
R_1	Col. 7 (*B* or *F*)	Col. 7 (*B* or *F*)	Col. 7 (*B* or *F*)
R_2	Col. 7 (*F, T. Dk*)	Not less than 2 rivets	Col. 7 (*F, T. Dk*)
T	Col. 4 or 5 (*B* or *F*) + ·08″ if already flanged	Col. 4 or 5 (*B* or *F*)	Col. 4 or 5 (*B* or *F*)
F	Flanged, if not flanged by col. 6 (*B* or *F*)	Col. 6 (*B* or *F*)	Col. 6 (*B* or *F*)

TABLE 28
(CONCLUDED)

AT THIRD DECK OF THREE DECK SHIPS AND OTHER LOWER DECKS

B	Col. 3 (*B*)	Col. 3 (*B*)	Col. 3 (*B*)
D	Col. 3 (*F*)	Col. 3 (*F*)	*See* D_2 below
D_1	Col. 3 (*F*, *T. Dk*)	Enough for rivets	Col. 3 (*F*, *T. Dk*)
D_2	Not less than col. 2 (*B*) or col. 3 (*F*)	Not less than col. 2 (*B*) or col. 3 (*F*)	Not less than col. 2 (*B*) or col. 3 (*F*)
R	Col. 7 (*F*)	Col. 7 (*B* or *F*) including R_2	Col. 7 (*B* or *F*) including R_2
R_1	Col. 7 (*B*)	Col. 7 (*B*)	Col. 7 (*B*)
R_2	Col. 7 (*F*, *T. Dk*)	Not less than 2 rivets	Col. 7 (*F*, *T. Dk*)
T	Col. 4 or 5 (*B* or *F*) + ·08″ if already flanged by col. 6 (*B*)	Col. 4 or 5 (*B*)	Col. 4 or 5 (*B*)
F	Flanged, if not flanged by col. 6 (*B*)	Col. 6 (*B*)	Col. 6 (*B*)

AT 'TWEEN DECK

B	Col. 3 (*B*)	Col. 3 (*B*)	Col. 3 (*B*)
D	Col. 3 (*B*)	Col. 3 (*B*)	*See* D_2 below
D_1	Col. 3 (*F*, *T. Dk*)	Enough for rivets	Col. 3 (*F*, *T. Dk*)
D_2	Not less than col. 2 (*B*)	Not less than col. 2 (*B*)	Col. 2 (*B*)
R	Col. 7 (*F*)	Col. 7 (*B* or *F*) including R_2	Col. 7 (*B*) including R_2
R_1	Col. 7 (*B*)	Col. 7 (*B*)	Col. 7 (*B*)
R_2	Col. 7 (*F*, *T. Dk*)	Not less than 2 rivets	Col. 7 (*F*, *T. Dk*)
T	Col. 4 or 5 (*B*)	Col. 4 or 5 (*B*)	Col. 4 or 5 (*B*)
F	Col. 6 (*B*) if required	Col. 6 (*B*) if required	Col. 6 (*B*) if required

TABLE 29

(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS							
		Inches 10 × ·32	Inches 11 × ·34	Inches 12 × ·34	Inches 13 × ·34	Inches 14 × ·34	Inches 15 × ·36	Inches 16 × ·36	Inches 17 × ·36
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS. (see also NOTE 4)							
		·30	*·30*	*·35*	*·40*	*·40*	*·45*	*·45*	*·50*
		FACE AREA							
	Inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches
50	19	·8							
100	21	2·6	2·1	1·7					
200	24	5·2	4·5	3·9	3·3	2·8			
300	27	7·1	6·2	5·5	4·8	4·2	3·6	3·2	2·7
400	30	9·9	8·7	7·8	6·9	6·1	5·4	4·8	4·3
600	33		13·8	12·4	11·1	10·0	9·0	8·2	7·4
800	36			17·0	15·4	14·0	12·6	11·6	10·6
1000	38			21·7	19·7	17·9	16·3	15·0	13·8
1200	40				23·9	21·8	20·0	18·5	17·0
1400	42						23·7	22·0	20·2
1600	44							25·5	23·4
1800	46								26·6
2000	48								
2200									
2400									
2600									

For notes see page 135

TABLE 29

(SEE CONTINUATION)

DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS								DEPTH OF END BRACKETS BELOW DECK	NUMERAL
Inches 18 × ·36	Inches 19 × ·38	Inches 20 × ·38	Inches 21 × ·38	Inches 22 × ·38	Inches 23 × ·40	Inches 24 × ·40	Inches 25 × ·40		
REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4)									
·50	*·55*	*·60*	*·60*	*·65*	*·65*	*·70*	*·70*		
FACE AREA									
Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Inches	
								19	50
								21	100
								24	200
2·3								27	300
3·8	3·3	2·8	2·5					30	400
6·8	6·0	5·4	5·0	4·5	3·9	3·5	3·1	33	600
9·8	8·9	8·1	7·5	6·9	6·2	5·7	5·2	36	800
12·8	11·7	10·8	10·1	9·3	8·6	7·9	7·4	38	1000
15·8	14·6	13·5	12·6	11·8	10·9	10·1	9·5	40	1200
18·8	17·4	16·2	15·2	14·2	13·2	12·3	11·6	42	1400
21·9	20·3	19·0	17·7	16·7	15·5	14·6	13·8	44	1600
24·9	23·2	21·7	20·3	19·1	17·9	16·8	15·9	46	1800
27·9	26·1	24·4	22·9	21·5	20·3	19·1	18·1	48	2000
		27·1	25·5	23·9	22·6	21·3	20·2		2200
				26·3	24·9	23·6	22·3		2400
							24·4		2600

For notes see page 135

TABLE 29

(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS										
		Inches 26×·40	Inches 27×·42	Inches 28×·42	Inches 29×·42	Inches 30×·42	Inches 31×·44	Inches 32×·44	Inches 33×·44	Inches 34×·44	Inches 35×·46	Inches 36×·46
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4)										
		·75	*·80*	*·80*	*·85*	*·85*	*·90*	*·90*	*·95*	*·95*	*1·00*	*1·00*
		FACE AREA										
	Inches	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.
50	19											
100	21											
200	24											
300	27											
400	30											
600	33											
800	36	4·7	4·2	3·8	3·3							
1000	38	6·8	6·1	5·6	5·2	4·7	4·1	3·7	3·3			
1200	40	8·9	8·1	7·6	7·0	6·5	5·8	5·4	4·9	4·5	3·9	3·4
1400	42	10·9	10·1	9·5	8·8	8·3	7·5	7·1	6·5	6·0	5·4	4·9
1600	44	13·0	12·1	11·4	10·6	10·1	9·3	8·7	8·1	7·6	6·9	6·4
1800	46	15·0	14·0	13·3	12·5	11·8	11·0	10·4	9·8	9·2	8·4	7·9
2000	48	17·1	16·0	15·2	14·3	13·6	12·7	12·0	11·4	10·7	9·9	9·3
2200		19·2	18·0	17·1	16·2	15·4	14·4	13·7	13·0	12·3	11·5	10·8
2400		21·2	20·0	19·0	18·0	17·2	16·1	15·4	14·6	13·9	13·0	12·3
2600		23·3	22·0	20·9	19·9	18·9	17·9	17·0	16·2	15·4	14·6	13·8
2800			24·0	22·9	21·8	20·7	19·6	18·7	17·8	17·0	16·1	15·2
3000				24·8	23·6	22·5	21·3	20·4	19·5	18·6	17·7	16·7

For notes see page 135

NOTES.—TABLE 29

1. Longitudinal girders.

The numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span of the girder, in feet, from pillar to pillar, or from pillar to bulkhead less half the distance between the toe of the end bracket and the bulkhead.

b = the mean width of deck, in feet, supported by the girder.

h is to be measured as follows :

(*a*) For decks on which cargo is carried h is the mean height in feet from top of beam to top of beam of the 'tween decks next above the girder.

(*b*) For decks under accommodation spaces h is 4 feet. (*See also* note 1 (*e*).)

(*c*) For weather decks, except in the forward ·12L, h is 4 feet if the draught does not exceed ·7D and 5 feet if the draught is ·85D or greater, with intermediate values in proportion, D being measured to the uppermost continuous deck. (*See also* note 1 (*e*).)

(*d*) Weather decks. For the forward ·075L h is to be 6 feet, irrespective of draught. Between ·075L and ·12L from forward, h is to be 5 feet, irrespective of draught.

(*e*) For decks above the uppermost continuous deck h, as given in (*b*) and (*c*), may be successively reduced by one foot for each deck to a minimum of 1·5 feet.

(*f*) Where decks support a hanging cargo, such as chilled meat, in addition to deck loads, the value of h is to be increased by 2·5 feet for one tier, 5 feet for two tiers and 7·5 feet for three tiers of quarters.

2. Strong hatch side coamings and end beams in 'tween decks.

(*a*) Side coamings.

The numeral for use in the Table is given by :

$$\frac{1{\cdot}1 \times l^2 \times b \times h}{100}$$

where l = the length of the hatchway in feet.

b = the mean breadth in feet of deck, including hatchway, supported by the coaming.

h = the mean height in feet of 'tween decks as in note 1.

(*b*) Hatch end beams.

For strong hatch end beams which are supported at the centre line and carry the hatch side coamings only, the numeral for use in the Table is given by :

$$\cdot 75\ B \times \frac{l \times b \times h}{100}$$

where B = the span of the hatch end beam, in feet, measured from the centre line to the ship's side less half the distance between the toe of the bracket and the ship's side.

l, b and h are measured as in note 2 (*a*).

Where the hatch end beam supports the hatch side coaming and, in addition, an adjacent longitudinal girder in line, the numeral is given by :

$$\cdot 75\ B \left(\frac{l_1 \times b_1 \times h}{100} + \frac{l_2 \times b_2 \times h}{100} \right)$$

where l_1, b_1, and h are measured as in note 2 (*a*) and l_2 and b_2 are measured as in note 1.

(*c*) The depth of strong hatch end beams derived from the Table is to be maintained for the full breadth of the ship.

(*d*) Strong hatch side coamings and end beams supporting deck longitudinals in association with transverses will be specially considered.

3. Transverses supporting deck longitudinals.

The numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span, in feet, of the transverse measured from pillar to pillar or from pillar to ship's side less half the distance between the toe of the bracket and the ship's side.

b is the length of deck in feet supported by the transverses.

h is measured as in note 1.

In single deck ships the depth of the transverses is to be increased by 15 per cent.

4. The sectional area of girder flanges derived from the Table may take the form of rolled sections, or flanged girder plates, with rider plates where necessary, the depth of the girder being measured to the bottom of the web. Where the depth of beam or longitudinal notches exceeds 50 per cent of the depth of the girder or 12 inches, whichever is less, the face area is to be suitably increased. The width of the flange is not to exceed the depth of the girder.

5. For end connections and constructional details *see* D 1505 to D 1515.

DECK RUNNERS

NUMERAL	DOUBLE ANGLES	SINGLE ANGLE OR BULB ANGLE
	Inches	Inches
5	3 × 2½ × ·26	3½ × 3 × ·36
10	3½ × 3 × ·30	5 × 3 × ·31
15	4 × 3 × ·32	5 × 3 × ·44
20	4 × 3 × ·40	5 × 3 × ·32
25	4 × 3 × ·45	5 × 3 × ·40
30	5 × 3 × ·36	5½ × 3 × ·34
35	5 × 3 × ·40	6 × 3 × ·32
40	5 × 3 × ·46	6 × 3 × ·38
45	6 × 3 × ·36	6 × 3 × ·48
50	6 × 3 × ·40	7 × 3 × ·36
55	6 × 3 × ·44	7 × 3 × ·40

ANGLES

BULB ANGLES

NOTES.—TABLE 30

1. The numeral is to be determined in accordance with Table 29, note 1.
2. The runners are to be fitted with the deep flange vertical.

TABLE 31

(SEE CONTINUATION)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR											
	Feet 8						Feet 12					
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
	OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS	
	Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches
4	$2\frac{1}{2}\times\cdot34$			$2\frac{3}{8}$	2	$\frac{7}{8}$	$3\frac{1}{2}\times\cdot34$			$2\frac{7}{8}$	2	$\frac{7}{8}$
6	$3\frac{1}{2}\times\cdot32$			$2\frac{5}{8}$	2	$\frac{7}{8}$	$4\times\cdot36$			$3\frac{1}{8}$	2	$\frac{7}{8}$
8	$4\times\cdot34$			$2\frac{7}{8}$	2	$\frac{7}{8}$	$4\frac{1}{2}\times\cdot36$			$3\frac{3}{8}$	2	$\frac{7}{8}$
10	$4\frac{1}{2}\times\cdot36$			$3\frac{1}{8}$	2	$\frac{7}{8}$	$5\times\cdot38$	$6\times3\times3\times\cdot36$		$3\frac{5}{8}$	3	$\frac{7}{8}$
15	$5\frac{1}{2}\times\cdot36$	$6\times3\times3\times\cdot36$		$3\frac{3}{8}$	3	$\frac{7}{8}$	$6\times\cdot40$	$6\times3\times3\times\cdot44$		$4\frac{1}{4}$	3	$\frac{7}{8}$
20	$6\times\cdot40$	$6\times3\times3\times\cdot44$		4	3	1	$7\times\cdot40$	$6\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot36$		5	4	1
30	$8\times\cdot40$	$7\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$		$4\frac{1}{2}$	4	1	$8\frac{1}{2}\times\cdot42$	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$		$5\frac{1}{2}$	5	1
40	$9\times\cdot44$	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$		5	5	1	$10\times\cdot44$	$9\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$		6	6	1
50	$10\times\cdot50$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$		$5\frac{1}{2}$	6	1	$11\times\cdot48$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot60$		$6\frac{1}{2}$	6	1
60	$11\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot60$		6	6	1	$11\times\cdot56$	$9\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$	$10\times\cdot40$			
70	$13\times\cdot52$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot44$	$10\times\cdot42$				$13\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$11\times\cdot46$			
85	$15\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot48$	$12\times\cdot50$				$15\times\cdot55$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot56$	$12\times\cdot50$			
100	$17\times\cdot56$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$12\times\cdot60$				$16\times\cdot62$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$	$13\times\cdot60$			
120	$18\times\cdot60$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot48$	$13\times\cdot70$				$18\times\cdot65$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$13\times\cdot74$			
140	$18\times\cdot66$						$20\times\cdot66$					
160	$20\times\cdot66$						$22\times\cdot66$					
180	$22\times\cdot68$						$24\times\cdot70$					
200	$24\times\cdot72$						$26\times\cdot74$					
220	$26\times\cdot74$						$26\times\cdot78$					
240	$26\times\cdot78$						$28\times\cdot80$					
260	$28\times\cdot80$						$30\times\cdot80$					

For notes see page 140

TABLE 31

(SEE CONTINUATION)

LENGTH AND FORM OF PILLAR												NUMERAL
Feet 16						Feet 20						
TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			
OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		
Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches	
4 × ·36			$3\frac{1}{4}$	2	$\frac{7}{8}$	$4\frac{1}{2}$ × ·38			$3\frac{7}{8}$	3	$\frac{7}{8}$	4
5 × ·36			$3\frac{3}{4}$	2	$\frac{7}{8}$	$5\frac{1}{2}$ × ·36			$4\frac{1}{4}$	3	$\frac{7}{8}$	6
$5\frac{1}{2}$ × ·38			4	3	$\frac{7}{8}$	6 × ·40			$4\frac{5}{8}$	3	$\frac{7}{8}$	8
6 × ·38	6 × 3 × 3 × ·44		$4\frac{1}{2}$	3	$\frac{7}{8}$	$6\frac{1}{2}$ × ·40	7 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·42		$5\frac{1}{4}$	4	$\frac{7}{8}$	10
7 × ·40	6 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·36		$5\frac{1}{4}$	4	$\frac{7}{8}$	8 × ·38	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38		6	4	1	15
8 × ·40	7 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38		6	5	1	$8\frac{1}{2}$ × ·42	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48					20
9 × ·44	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48					10 × ·44	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50					30
10 × ·48	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50					11 × ·48	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·38	10 × ·40				40
11 × ·50	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46	10 × ·40				12 × ·52	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	11 × ·44				50
12 × ·55	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50	11 × ·46				13 × ·54	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·56	12 × ·50				60
14 × ·52	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·56	12 × ·52				14 × ·58	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·56	12 × ·60				70
15 × ·58	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·46	13 × ·60				16 × ·60	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	13 × ·72				85
17 × ·57	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·50	13 × ·70				17 × ·66						100
19 × ·64						19 × ·68						120
20 × ·70						22 × ·68						140
22 × ·72						23 × ·72						160
24 × ·72						25 × ·74						180
26 × ·74						27 × ·78						200
27 × ·79						28 × ·82						220
29 × ·80						31 × ·82						240
31 × ·82												260

For notes see page 140

TABLE 31
(CONCLUDED)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR											
	Feet 24						Feet 28					
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
	OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS	
	Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches
4				$4\frac{3}{8}$	3	$\frac{7}{8}$				$4\frac{7}{8}$	4	$\frac{7}{8}$
6				$4\frac{3}{4}$	3	$\frac{7}{8}$				$5\frac{1}{2}$	4	$\frac{7}{8}$
8	7 × ·38			$5\frac{1}{2}$	4	$\frac{7}{8}$	8 × ·38			6	4	1
10	$7\frac{1}{2}$×·38	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·46		6	4	1	$8\frac{1}{2}$×·40	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·52				
15	$8\frac{1}{2}$×·40	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·50					9 × ·44	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·52				
20	9 × ·44	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·52					10 × ·42	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·60				
30	10 × ·48	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·60					11 × ·48	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·44	10×·42			
40	11 × ·52	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	10×·42				12 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	11×·46			
50	13 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	12×·50				14 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·56			
60	14 × ·56	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·60				15 × ·56	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·64			
70	15 × ·58	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·70				16 × ·60	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	13×·74			
85	17 × ·62	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·74				18 × ·62					
100	19 × ·64						19 × ·66					
120	20 × ·70						21 × ·70					
140	23 × ·70											
160	25 × ·72											
180	26 × ·80											
200	29 × ·80											
220												
240												
260												

NOTES.—TABLE 31

1. The numeral for use in the Table is to be the sum of the numerals representing the separate loads which may be transmitted to the pillar, namely :

(*a*) The numeral in respect of that proportion of the deck load, supported by a girder, hatch end beam or deck transverse, which is borne by the pillar.

(*b*) The numeral of the directly superimposed pillar, if any.

2. The numeral is to be determined by :

$$\frac{s \times b \times h}{100}$$

where s = the distance in feet between the centres of the two adjacent spans of girder supported by the pillar.

b = the mean width of deck, including hatchway if necessary, supported by the girders over the distance s.

h is to be measured as defined in Table 29, note 1.

3. Pillars equivalent to those shown in the Tables, of riveted or welded construction, will be accepted.

When hollow square pillars are fitted, the thickness is to be the same as that of the tubular pillar required and the side is to be 80 per cent of the diameter of the tubular pillar.

4. When solid pillars are fitted in pairs to take shifting boards, their diameter is to be 75 per cent of that required by the Table.

5. For end connections and constructional details *see* D 1516 to D 1524.

BULKHEAD PLATING

Stiffeners spaced 30 inches apart on watertight bulkheads and 24 inches apart on collision, deep tank, peak tank and oil fuel bunker bulkheads

DEPTH (*See* NOTE 1)	THICKNESS	DEPTH (*See* NOTE 1)	THICKNESS
Feet	Inches	Feet	Inches
8	·26	36	·40
12	·28	40	·42
16	·30	44	·44
20	·32	48	·46
24	·34	52	·48
28	·36	56	·50
32	·38	60	·52

NOTES.—TABLE 32

1. Depth is to be measured as follows :—

(*a*) For watertight bulkheads (D 16). From the lower edge of the plate to the top of the bulkhead at the centre line.

(*b*) For bulkheads of tanks (D 19 and D 20). From the lower edge of the plate to the top of the tank or to a point midway between the half-depth of the tank and the top of the overflow, whichever distance is greater.

2. Correction for spacing of stiffeners. Where the spacing of stiffeners differs from that given in the Table the thickness of the plating is to be modified at the rate of 2 per cent for every inch of difference except that where the spacing on tank or oil bunker bulkheads exceeds 24 inches the thickness is to be increased at the rate of 3 per cent per inch difference of spacing.

3. Additions to thickness, as corrected by note 2, are to be made as follows :—

(*a*) To the lowest strake of hold and tank bulkheads ... ... ·04 inch.

(*b*) To the lowest strake of stokehold bulkheads in coal burning ships ... ... ·10 inch.

(*c*) Plates in limbers and at the bottom of peak bulkheads ... ... ·10 inch.

(*d*) In way of the stern tube, plating to be increased substantially or doubled.

4. The plating of deep tank, peak tank and oil fuel bunker bulkheads in ships exceeding 150 feet in length is not to be less than ·30 inch after correction.

TABLE 33

(SEE CONTINUATION)

BULKHEAD STIFFENER

Spaced 24 inches apart on collision bulkhea

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
		0	2	4	6	8	10	12
Feet		INCHES — *Modulus—Inches*^{3}						
8	ANGLES	4 × 3 × ·30 *1·65*	4 × 3 × ·38 *2·10*	4 × 3 × ·43 *2·35*	5 × 3 × ·32 *2·70*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*
9	ANGLES	4 × 3 × ·40 *2·20*	5 × 3 × ·32 *2·70*	5 × 3 × ·36 *3·00*	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*
10	ANGLES	5 × 3 × ·34 *2·85*	5 × 3 × ·42 *3·50*	6 × 3 × ·34 *4·10*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*
11	ANGLES	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*
12	ANGLES	6 × 3 × ·38 *4·55*	5½ × 3 × ·36 *5·80*	6 × 3 × ·35 *6·95*	6 × 3 × ·38 *7·35*	6 × 3 × ·47 *8·60*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*
13	BULB ANGLES	5½ × 3 × ·37 *5·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*
14	BULB ANGLES	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*
15	BULB ANGLES	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*
16	BULB ANGLES	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*
17	BULB ANGLES	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
18	BULB ANGLES	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*
19	BULB ANGLES	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*
20	BULB ANGLES	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·55 *29·15*	*30·90*	11 × 3½ × ·53 *35·00*
21	BULB ANGLES	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*
22	BULB ANGLES	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
23	BULB ANGLES	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 4 × 4 × ·4 *45·40*
24	BULB ANGLES	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·5 *48·60*
25	BULB ANGLES	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·6 *53·75*
26	BULB ANGLES	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·64 *52·60*	*55·50*	
27	BULB ANGLES	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·50 *47·00*	*54·50*	*58·60*		

For notes see page 149

Section moduli above ar

and 30 inches apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET							LENGTH OF STIFFENER
14	16	18	20	22	24	26	
INCHES — Modulus—Inches³							Feet
6 × 3 × ·36 *4·30*	5½ × 3 × ·28 *4·95*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·39 *7·50*	8
5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	6 × 3 × ·50 *9·00*	7 × 3 × ·37 *10·10*	9
6 × 3 × ·38 *7·35*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	10
7 × 3 × ·36 *9·95*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·42 *14·75*	11
7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·38 *18·40*	12
8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·90*	13
8 × 3 × ·49 *16·35*	9 × 3½ × ·38 *18·40*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	14
9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·52 *28·10*	*30·90*	15
9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*	16
10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	17
30·90	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	18
11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*	12×4×4×·48 *46·20*	19
11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*	20
12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·67 *53·75*	*57·50*	21
12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*	22
12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*		23
12 × 4 × 4 × ·64 *52·60*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*				24
							25
							26
							27

BULB ANGLES

CHANNELS

For notes see page 149

† *given to nearest ·05*

TABLE 33 (CONCLUDED) BULKHEAD STIFFENERS—BRACKETED

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
	28	30	32	34	36	38	40
Feet	INCHES — *Modulus—Inches*^{3}						
8	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·38 *10·25*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*
9	7 × 3 × ·40 *10·60*	7 × 3 × ·47 *11·85*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·38 *13·85*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*
10	7 × 3 × ·51 *12·60*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·48 *16·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*
11	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*
12	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*
13	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*
14	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
15	11 × 3½ × ·44 *31·55*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
16	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
17	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*
18	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*
19	12×4×4×·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15×4×4×·48 *64·60*
20	12×4×4×·67 *53·75*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*		
21	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
22	15×4×4×·50 *65·85*						
23							
24							
25							
26							
27							

BULB ANGLES (8 to 18 Feet) — CHANNELS (19 to 27 Feet) — BULB ANGLES

For notes see page 149

Section moduli are given to nearest ·05

TABLE 34

(SEE CONTINUATION)

BULKHEAD STIFFENERS

Spaced 24 inches apart on collision bulkhead

LENGTH OF STIFFENER	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
	0	2	4	6	8	10	12
Feet	INCHES — *Modulus—Inches³*						
8	*4 × 3 × ·43 *2·35*	5 × 3 × ·36 *3·00*	5 × 3 × ·46 *3·80*	6 × 3 × ·38 *4·55*	5½ × 3 × ·36 *5·80*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*
9	*5 × 3 × ·42 *3·50*	5 × 3 × ·47 *3·90*	5½ × 3 × ·36 *5·80*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·39 *7·50*	6 × 3 × ·46 *8·45*
10	*6 × 3 × ·38 *4·55*	5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*
11	5½ × 3 × ·38 *6·05*	6 × 3 × ·38 *7·35*	6 × 3 × ·46 *8·45*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*
12	6 × 3 × ·39 *7·50*	6 × 3 × ·50 *9·00*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·54 *13·15*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*
13	6 × 3 × ·45 *8·35*	7 × 3 × ·40 *10·60*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*
14	7 × 3 × ·41 *10·80*	7 × 3 × ·52 *12·80*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*
15	7 × 3 × ·52 *12·80*	8 × 3 × ·45 *15·45*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*
16	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·44 *31·55*
17	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·56 *36·20*
18	9 × 3½ × ·51 *21·90*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*
19	10 × 3½ × ·42 *24·80*	10 × 3½ × ·53 *28·45*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·58 *37·00*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 4 × 4 × ·48 *46·20*
20	*30·90*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	13 × 4 × 4 × ·62 *51·80*
21	11 × 3½ × ·46 *32·30*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	*57·50*
22	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	15 × 4 × 4 × ·46 *63·35*
23	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	
24	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·56 *49·40*	*54·50*	*59·70*	15 × 4 × 4 × ·48 *64·60*		
25	12×4×4×·54 *48·60*	*55·50*	*60·80*	15 × 4 × 4 × ·50 *65·85*			
26	*54·50*	15 × 4 × 4 × ·44 *62·15*	15 × 4 × 4 × ·53 *67·65*				
27	*60·80*	15 × 4 × 4 × ·55 *68·85*					

ANGLES (Feet 8–10) · BULB ANGLES (Feet 11–24) · CHANNELS (Feet 25–27)

The ends of upper 'tween deck stiffeners marked * may be riveted to the boundary angle only, without lug attachment

Section moduli above are

and 30 inches apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET							LENGTH OF STIFFENER	
14	16	18	20	22	24	26		
INCHES — *Modulus—Inches³*							Feet	
6 × 3 × ·40 *7·65*	6 × 3 × ·47 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*	7 × 3 × ·41 *10·80*	7 × 3 × ·48 *12·05*	BULB ANGLES	8
7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·43 *11·15*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*		9
7 × 3 × ·48 *12·05*	7 × 3 × ·52 *12·80*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*		10
8 × 3 × ·42 *14·75*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*		11
9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*		12
9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*		13
10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*		14
30·90	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*		15
11 × 3½ × ·45 *31·95*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12×4×4×·62 *51·80*		16
11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*		17
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*		18
12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*59·70*	15 × 4 × 4 × ·46 *63·35*				19
12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·53 *67·65*					20
59·70	15 × 4 × 4 × ·50 *65·85*						CHANNELS	21
								22
								23
								24
								25
								26
								27

For notes see page 149

given to nearest ·05

TABLE 34 (CONCLUDED) BULKHEAD STIFFENERS—LUGGED

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
	28	30	32	34	36	38	40
Feet	INCHES — *Modulus—Inches³*						
8	7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·43 *15·00*	8 × 3 × ·51 *16·85*	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*
9	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
10	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*
11	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*
12	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
13	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
14	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*
15	12×4×4×·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15×4×4×·46 *63·35*
16	12×4×4×·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*	15 × 4 × 4 × ·50 *65·85*	
17	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
18	15×4×4×·53 *67·65*						
19							
20							
21							
22							
23							
24							
25							
26							
27							

BULB ANGLES — CHANNELS — BULB ANGLES — CHANNELS

For notes see page 149

Section moduli above are given to nearest ·05

TABLE 35

BULKHEAD STIFFENERS in TUGS

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER		STIFFENERS BRACKETED AT ENDS	STIFFENERS WITHOUT BRACKETS OR LUGS AT ENDS
Feet		INCHES *Modulus—Inches*^{3}	INCHES *Modulus—Inches*^{3}
7	ANGLES ↑	—	$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot 30$ *1·30*
8		$3 \times 2\frac{1}{2} \times \cdot 28$ *·90*	$4 \times 3 \times \cdot 30$ *1·65*
9		$3 \times 2\frac{1}{2} \times \cdot 30$ *1·00*	$4 \times 3 \times \cdot 34$ *1·90*
10		$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot 32$ *1·40*	$4 \times 3 \times \cdot 43$ *2·35*
11		$4 \times 3 \times \cdot 32$ *1·80*	$5 \times 3 \times \cdot 34$ *2·85*
12		$4 \times 3 \times \cdot 40$ *2·20*	$5 \times 3 \times \cdot 42$ *3·50*
13		$5 \times 3 \times \cdot 32$ *2·70*	$6 \times 3 \times \cdot 36$ *4·30*
14		$5 \times 3 \times \cdot 42$ *3·50*	$6 \times 3 \times \cdot 42$ *5·00*
15		$6 \times 3 \times \cdot 36$ *4·30*	$6 \times 3 \times \cdot 49$ *5·75*
16	↓	$6 \times 3 \times \cdot 42$ *5·00*	—

TABLE 36

END ATTACHMENTS for STIFFENERS

TYPE AND DEPTH OF STIFFENER		BRACKET ATTACHMENTS				LUG ATTACHMENTS	
		Thickness of bracket	Width of flange	Number and size of rivets in each arm of bracket	Area of weld	Number and size of rivets in lugs	Area of weld
		Inches	Inches		Sq. inches		Sq. inches
Angles		·34	—	3 of $\frac{3}{4}$ Ins. Dia.	1·5	2 of $\frac{3}{4}$ Ins. Dia.	1·0
Bulb angles 6 inches & under		·36	—	3 „ $\frac{3}{4}$ „ „	1·5	2 „ $\frac{3}{4}$ „ „	1·0
Bulb angles 7 inches		·40	—	4 „ $\frac{3}{4}$ „ „	2·0	3 „ $\frac{3}{4}$ „ „	1·5
„ „ 8 „		·42	—	5 „ $\frac{3}{4}$ „ „	2·5	3 „ $\frac{3}{4}$ „ „	1·5
„ „ 9 „	FLANGED ↑	·34	$2\frac{1}{4}$	6 „ $\frac{3}{4}$ „ „	3·0	4 „ $\frac{3}{4}$ „ „	2·0
„ „ 10 „		·36	$2\frac{1}{2}$	7 „ $\frac{3}{4}$ „ „	3·5	4 „ $\frac{3}{4}$ „ „	2·0
„ „ 11 „		·38	$2\frac{3}{4}$	7 „ $\frac{7}{8}$ „ „	4·75	4 „ $\frac{7}{8}$ „ „	2·75
„ „ 12 „		·40	3	8 „ $\frac{7}{8}$ „ „	5·5	5 „ $\frac{7}{8}$ „ „	3·5
Channels $12 \times 3\frac{1}{2} \times 3\frac{1}{2}$ inches		·40	3	9 „ $\frac{7}{8}$ „ „	6·25	6 „ $\frac{7}{8}$ „ „	4·0
„ $12 \times 4 \times 4$ inches		·40	3	10 „ $\frac{7}{8}$ „ „	7·0	7 „ $\frac{7}{8}$ „ „	4·75
„ $15 \times 4 \times 4$ inches	↓	·44	$3\frac{1}{2}$	13 „ $\frac{7}{8}$ „ „	9·0	8 „ $\frac{7}{8}$ „ „	5·5

NOTES.—TABLES 33, 34, 35 & 36

1. Length of stiffeners is to be measured over the full distance between the top and bottom boundaries of the bulkhead.

2. Correction for spacing.—If the spacing of the stiffeners differs from the Table spacing the modulus is to be modified in direct proportion.

3. Welded construction.—When the bulkhead plating, boundaries, stiffeners and end brackets are welded, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

4. Area of weld is the product of the throat thickness and the length of the weld. The throat thickness is not to be less than 70 per cent of the leg length for Type 3 weld. (*See* Table 52 G.)

5. Particulars of sections and moduli are given in Table 56.

TABLE 37

TUNNEL PLATING

Stiffeners spaced 36 inches apart

DEPTH (*See* NOTE 1)	THICKNESS		DEPTH (*See* NOTE 1)	THICKNESS	
	FLAT SIDE PLATING	CURVED TOP PLATING		FLAT SIDE PLATING	CURVED TOP PLATING
Feet	Inches	Inches	Feet	Inches	Inches
8	·29	·26	36	·45	·40
12	·31	·28	40	·47	·42
16	·33	·30	44	·49	·44
20	·35	·32	48	·51	·46
24	·38	·34	52	·54	·48
28	·40	·36	56	·56	·50
32	·42	·38	60	·58	·52

NOTES.—TABLE 37

1. Depth is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the lower edge of the plate.

2. Correction for spacing of stiffeners. When the spacing differs from 36 inches the thickness is to be modified at the rate of 2 per cent for every inch of difference.

3. For additions under hatchways *see* D 1702 to D 1703.

For tunnels in deep tanks *see* D 1910 and D 2014.

TUNNEL STIFFENERS

Spaced 36 inches apart

DEPTH (*See* NOTE 1)	LENGTH FROM BASE OF TUNNEL TO TOP OF FLAT SIDE					
	Feet 3	Feet 4	Feet 5	Feet 6	Feet 7	Feet 8
Feet	INCHES — *Modulus—Inches*³					
12	3 × 2½ × ·24 *·80*	3½ × 3 × ·34 *1·45*	4 × 3 × ·38 *2·10*	5 × 3 × ·34 *2·85*	5 × 3 × ·44 *3·65*	5½ × 3 × ·35 *5·70*
16	3 × 2½ × ·29 *·95*	4 × 3 × ·30 *1·65*	5 × 3 × ·32 *2·70*	5 × 3 × ·44 *3·65*	5½ × 3 × ·35 *5·70*	6 × 3 × ·35 *6·95*
20	3½ × 2½ × ·26 *1·15*	4 × 3 × ·38 *2·10*	5 × 3 × ·42 *3·50*	6 × 3 × ·38 *4·55*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*
24	4 × 3 × ·28 *1·55*	5 × 3 × ·32 *2·70*	6 × 3 × ·32 *3·90*	5½ × 3 × ·37 *5·95*	6 × 3 × ·38 *7·35*	7 × 3 × ·37 *10·10*
28	4 × 3 × ·30 *1·65*	5 × 3 × ·36 *3·00*	6 × 3 × ·40 *4·75*	6 × 3 × ·35 *6·95*	6 × 3 × ·48 *8·75*	7 × 3 × ·48 *12·05*
32	4 × 3 × ·38 *2·10*	5 × 3 × ·42 *3·50*	5½ × 3 × ·37 *5·95*	6 × 3 × ·45 *8·35*	7 × 3 × ·39 *10·45*	8 × 3 × ·39 *14·10*
36	4 × 3 × ·40 *2·20*	6 × 3 × ·32 *3·90*	6 × 3 × ·35 *6·95*	6 × 3 × ·48 *8·75*	7 × 3 × ·47 *11·85*	8 × 3 × ·42 *14·75*
40	4 × 3 × ·43 *2·35*	6 × 3 × ·38 *4·55*	6 × 3 × ·36 *7·10*	7 × 3 × ·37 *10·10*	8 × 3 × ·39 *14·10*	8 × 3½ × ·52 *17·15*
44	5 × 3 × ·32 *2·70*	6 × 3 × ·40 *4·75*	6 × 3 × ·45 *8·35*	7 × 3 × ·48 *12·05*	8 × 3 × ·42 *14·75*	9 × 3½ × ·41 *19·15*
48	5 × 3 × ·36 *3·00*	5½ × 3 × ·35 *5·70*	6 × 3 × ·47 *8·60*	7 × 3 × ·49 *12·25*	8 × 3½ × ·49 *16·45*	9 × 3½ × ·45 *20·20*
52	5 × 3 × ·42 *3·50*	5½ × 3 × ·37 *5·95*	7 × 3 × ·37 *10·10*	8 × 3 × ·39 *14·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·52 *22·20*
56	5 × 3 × ·44 *3·65*	6 × 3 × ·35 *6·95*	7 × 3 × ·39 *10·45*	8 × 3 × ·42 *14·75*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·60 *24·45*
60	6 × 3 × ·32 *3·90*	6 × 3 × ·36 *7·10*	7 × 3 × ·48 *12·05*	8 × 3½ × ·49 *16·45*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·50 *27·40*

ANGLES — BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 38

1. Depth is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the base of the tunnel.

2. Correction for spacing. If the spacing of the stiffeners differs from 36 inches the Table modulus is to be modified in direct proportion.

3. Particulars of sections and moduli are given in Table 56.

TABLE 39

STIFFENERS TO NON-

LENGTH OF STIFFENER		NUMERAL					
		NOT EXCEEDING 5	10	15	20	30	40
		<- SINGLE STIFFENERS ->				<- DOUBLE STIFFENERS ->	
Feet		Inches	Inches	Inches	Inches	Inches	Inches
8	ANGLES	4 × 3 × ·32	5 × 3 × ·36	5½×3 × ·34	6 × 3 × ·40	5 × 3 × ·30	5½×3 × ·38
10	ANGLES	5 × 3 × ·32	5½×3 × ·32	6 × 3 × ·34	7 × 3 × ·36	5½×3 × ·30	6 × 3 × ·38
12	ANGLES	5 × 3 × ·36	6 × 3 × ·32	7 × 3 × ·34	8 × 3 × ·36	6 × 3 × ·32	6 × 3 × ·44
14	ANGLES	5 × 3 × ·40	6 × 3 × ·38	7 × 3 × ·40	8 × 3 × ·42	6 × 3 × ·36	7 × 3 × ·42
16	BULB ANGLES	6 × 3 × ·32	7 × 3 × ·36	8 × 3 × ·36	9 × 3½×·40	7 × 3 × ·36	8 × 3 × ·42
18	BULB ANGLES	6 × 3 × ·38	7 × 3 × ·42	8 × 3 × ·42	9 × 3½×·46	7 × 3 × ·40	8 × 3 × ·46
20	BULB ANGLES	7 × 3 × ·38	8 × 3 × ·42	9 × 3½×·42	10 × 3½×·48	8 × 3 × ·40	9 × 3½×·44
22	BULB ANGLES	7 × 3 × ·44	8 × 3 × ·48	9 × 3½×·50	10 × 3½×·56	8 × 3 × ·44	9 × 3½×·50
24	BULB ANGLES	8 × 3 × ·40	9 × 3½×·44	10 × 3½×·48	11 × 3½×·54	9 × 3½×·42	10 × 3½×·48
26	BULB ANGLES	8 × 3 × ·46	9 × 3½×·50	10 × 3½×·54	11 × 3½×·60	9 × 3½×·46	10 × 3½×·54
28	BULB ANGLES	9 × 3½×·42	10 × 3½×·48	11 × 3½×·52	12 × 3½×·58	10 × 3½×·42	11 × 3½×·50
30	BULB ANGLES	9 × 3½×·48	10 × 3½×·54	11 × 3½×·56	12 × 3½×·62	10 × 3½×·46	11 × 3½×·56
32	BULB ANGLES	10 × 3½×·44	11 × 3½×·48	11 × 3½×·58	12 × 3½×·66	11 × 3½×·44	12 × 3½×·52

NOTES.—TABLE 39

1. Length of stiffener is to be measured between the top and bottom boundaries of the bulkhead.

2. The numeral, whether for stiffeners supporting deck beams, strong hatch end beams or deck transverses, is to be obtained as for pillars: *see* Table 31, notes 1 and 2.

3. Arrangements with longitudinally framed decks.—The stiffeners not supporting deck transverses are to have a modulus 25 per cent less than that derived from the column headed "Not exceeding 5". The ends of hold

TABLE 39

NUMERAL 50	NUMERAL 60	NUMERAL 70	NUMERAL 80	NUMERAL 90	LENGTH OF STIFFENER
DOUBLE STIFFENERS.					
Inches	Inches	Inches	Inches	Inches	Feet
6 × 3 × ·38	6 × 3 × ·42	7 × 3 × ·42	8 × 3 × ·40	8 × 3 × ·46	8
6 × 3 × ·42	7 × 3 × ·42	7 × 3 × ·46	8 × 3 × ·44	8 × 3 × ·50	10
7 × 3 × ·42	8 × 3 × ·42	8 × 3 × ·46	8 × 3 × ·50	9 × 3½ × ·50	12
8 × 3 × ·40	8 × 3 × ·44	9 × 3½ × ·46	9 × 3½ × ·50	10 × 3½ × ·52	14
8 × 3 × ·46	9 × 3½ × ·46	9 × 3½ × ·52	10 × 3½ × ·52	10 × 3½ × ·58	16
9 × 3½ × ·44	9 × 3½ × ·50	10 × 3½ × ·52	10 × 3½ × ·56	11 × 3½ × ·56	18
9 × 3½ × ·50	10 × 3½ × ·50	10 × 3½ × ·58	11 × 3½ × ·56	11 × 3½ × ·60	20
10 × 3½ × ·50	10 × 3½ × ·56	11 × 3½ × ·56	11 × 3½ × ·60	12 × 3½ × ·60	22
10 × 3½ × ·56	11 × 3½ × ·54	12 × 3½ × ·56	12 × 3½ × ·60		24
11 × 3½ × ·54	11 × 3½ × ·60	12 × 3½ × ·60			26
11 × 3½ × ·60	12 × 3½ × ·60				28
12 × 3½ × ·56					30
12 × 3½ × ·60					32

BULB ANGLES

NOTES.—TABLE 39 *(concluded)*

stiffeners are to be lugged or welded to the inner bottom and deck.

4. Coal bunker bulkheads.—The scantlings of stiffeners for bunker bulkheads, not supporting decks, are to be determined from the column headed "Not exceeding 5" for a spacing of 36 inches, but the modulus may be reduced by 25 per cent.

5. For end connections and constructional details *see* D 18.

TABLE 40 STIFFENERS ON BOUNDARY BULKHEADS OF DEEP TANKS,

Spaced 24 inches apart

LENGTH OF STIFFENER		HEAD H FEET							
		3	4	5	6	8	10	12	14
Feet		INCHES *Modulus—Inches³*							
5	ANGLES	3 × 3 × ·26 ·85	3 × 3 × ·30 1·00	3½ × 3 × ·28 1·20	3½ × 3 × ·32 1·40	4 × 3 × ·34 1·90	4 × 3 × ·44 2·40	5 × 3 × ·33 2·80	5 × 3 × ·39 3·25
6	ANGLES	3 × 3 × ·30 1·00	3½ × 3 × ·32 1·40	4 × 3 × ·31 1·70	4 × 3 × ·38 2·10	5 × 3 × ·33 2·80	5 × 3 × ·41 3·40	6 × 3 × ·34 4·10	6 × 3 × ·39 4·65
7	ANGLES	3½ × 3 × ·32 1·40	4 × 3 × ·38 2·10	5 × 3 × ·30 2·55	5 × 3 × ·34 2·85	6 × 3 × ·32 3·90	6 × 3 × ·41 4·85	5½ × 3 × ·35 5·70	6 × 3 × ·32 6·50
8	ANGLES	4 × 3 × ·34 1·90	5 × 3 × ·30 2·55	5 × 3 × ·37 3·10	6 × 3 × ·30 3·70	6 × 3 × ·42 5·00	5½ × 3 × ·40 6·25	6 × 3 × ·39 7·50	6 × 3 × ·48 8·75
9	ANGLES	4 × 3 × ·44 2·40	5 × 3 × ·39 3·25	6 × 3 × ·33 4·00	6 × 3 × ·40 4·75	5½ × 3 × ·40 6·25	6 × 3 × ·42 7·90	6 × 3 × ·52 9·30	7 × 3 × ·41 10·80
10	ANGLES	5 × 3 × ·34 2·85	6 × 3 × ·34 4·10	6 × 3 × ·42 5·00	5½ × 3 × ·36 5·80	6 × 3 × ·42 7·90	7 × 3 × ·34 9·60	7 × 3 × ·46 11·65	8 × 3 × ·36 13·45
11	ANGLES	5 × 3 × ·42 3·55	6 × 3 × ·42 5·00	5½ × 3 × ·34 5·60	6 × 3 × ·36 7·10	7 × 3 × ·33 9·45	7 × 3 × ·45 11·50	8 × 3 × ·37 13·65	8 × 3 × ·46 15·65
12	ANGLES	6 × 3 × ·37 4·55	5½ × 3 × ·36 5·80	5½ × 3 × ·46 6·95	6 × 3 × ·44 8·20	7 × 3 × ·42 10·95	8 × 3 × ·36 13·45	8 × 3 × ·47 15·90	9 × 3½ × ·38 18·40
13	ANGLES	6 × 3 × ·43 5·10	5½ × 3 × ·43 6·60	6 × 3 × ·43 8·05	7 × 3 × ·34 9·60	7 × 3 × ·52 12·80	8 × 3 × ·48 16·10	9 × 3½ × ·41 19·15	9 × 3½ × ·50 21·60
14	BULB ANGLES	5½ × 3 × ·34 5·60	6 × 3 × ·38 7·35	6 × 3 × ·52 9·30	7 × 3 × ·44 11·30	8 × 3 × ·44 15·20	9 × 3½ × ·39 18·65	9 × 3½ × ·52 22·20	10 × 3½ × ·44 25·45
15	BULB ANGLES	6 × 3 × ·34 6·80	6 × 3 × ·50 9·00	7 × 3 × ·43 11·15	8 × 3 × ·36 13·45	8 × 3 × ·55 17·80	9 × 3½ × ·52 22·20	10 × 3½ × ·46 26·10	10 × 3½ × ·57 29·45
16	BULB ANGLES	6 × 3 × ·42 7·90	7 × 3 × ·40 10·60	7 × 3 × ·53 13·00	8 × 3 × ·44 15·20	9 × 3½ × ·47 20·80	10 × 3½ × ·43 25·15	10 × 3½ × ·56 29·45	11 × 3½ × ·48 33·05
17	BULB ANGLES	6 × 3 × ·52 9·15	7 × 3 × ·50 12·40	8 × 3 × ·44 15·20	8 × 3 × ·55 17·80	9 × 3½ × ·54 22·70	10 × 3½ × ·55 29·15	11 × 3½ × ·50 33·80	11 × 3½ × ·62 38·60
18	BULB ANGLES	7 × 3 × ·39 10·45	8 × 3 × ·39 14·10	8 × 3 × ·53 17·35	9 × 3½ × ·46 20·50	10 × 3½ × ·45 25·80	11 × 3½ × ·49 33·45	12 × 3½ × ·46 39·45	12 × 4 × 4 × ·46 45·40
19	BULB ANGLES	7 × 3 × ·49 12·15	8 × 3 × ·49 16·35	9 × 3½ × ·45 20·20	9 × 3½ × ·58 23·85	10 × 3½ × ·60 30·80	11 × 3½ × ·62 38·60	12 × 3½ × 3½ × ·54 45·30	12 × 4 × 4 × ·61 51·40
20	BULB ANGLES	8 × 3 × ·38 13·85	9 × 3½ × ·38 18·40	9 × 3½ × ·54 22·70	10 × 3½ × ·49 27·10	11 × 3½ × ·55 35·8	12 × 4 × 4 × ·44 44·60	12 × 4 × 4 × ·62 51·80	 58·70
21	BULB ANGLES	8 × 3 × ·46 15·75	9 × 3½ × ·48 21·05	10 × 3½ × ·46 26·10	 31·25	12 × 3½ × ·50 41·20	12 × 4 × 4 × ·60 51·00	 59·80	15 × 4 × 4 × ·50 65·85
22	BULB ANGLES	8 × 3 × ·55 17·80	9 × 3½ × ·58 23·85	10 × 3½ × ·56 29·45	11 × 3½ × ·54 35·40	12 × 4 × 4 × ·49 46·60	 57·60	15 × 4 × 4 × ·52 67·05	 76·90
23	BULB ANGLES	9 × 3½ × ·48 21·05	10 × 3½ × ·49 27·10	11 × 3½ × ·49 33·45	12 × 3½ × ·47 39·90	12 × 4 × 4 × ·64 52·60	15 × 4 × 4 × ·48 64·60	 76·90	17 × 4 × 4 × ·56 86·10
24	BULB ANGLES	10 × 3½ × ·40 24·20	10 × 3½ × ·58 30·10	11 × 3½ × ·57 37·40	12 × 3½ × 3½ × ·52 44·50	 59·40	15 × 4 × 4 × ·60 71·80	17 × 4 × 4 × ·56 86·10	17 × 4 × 4 × ·74 99·25

Section moduli above are given to nearest ·05

NOTES.—TABLE 40

1. Length of stiffeners on bulkheads is to be measured as follows :—

(*a*) Where horizontal girders are not fitted :
between the top and bottom boundaries.

(*b*) Where horizontal girders are fitted :

(i) between the top boundary and the highest girder,

(ii) between girder and girder,

(iii) between the lowest girder and the bottom boundary.

On tunnels passing through deep tanks and having a curved top, the length of stiffeners is to be measured from the base of the tunnel to the top of the flat side.

2. Head H is to be taken as the greater of the two following values :—

(*a*) the distance in feet from the mid-point of length as defined above to the top of the tank.

Spaced 24 inches apart

HEAD H FEET 16	18	20	22	24	26	28		LENGTH OF STIFFENER
INCHES *Modulus—Inches*[3]								Feet
5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*	6 × 3 × ·37 *4·40*	6 × 3 × ·40 *4·75*	6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·36 *7·10*	BULB ANGLES	5
6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·31 *6·40*	6 × 3 × ·36 *7·10*	6 × 3 × ·40 *7·65*	6 × 3 × ·44 *8·20*	6 × 3 × ·48 *8·75*		6
6 × 3 × ·38 *7·35*	6 × 3 × ·44 *8·20*	6 × 3 × ·50 *9·00*	7 × 3 × ·36 *9·95*	7 × 3 × ·40 *10·60*	7 × 3 × ·44 *11·30*	7 × 3 × ·48 *12·05*		7
7 × 3 × ·35 *9·80*	7 × 3 × ·42 *10·95*	7 × 3 × ·48 *12·05*	8 × 3 × ·35 *13·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·43 *15·00*	8 × 3 × ·47 *15·90*		8
7 × 3 × ·49 *12·25*	8 × 3 × ·37 *13·65*	8 × 3 × ·44 *15·20*	8 × 3 × ·49 *16·35*	8 × 3 × ·55 *17·80*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*		9
8 × 3 × ·44 *15·20*	8 × 3 × ·51 *16·85*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*		10
8 × 3 × ·54 *17·55*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*		11
9 × 3½ × ·46 *20·50*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·49 *33·45*		12
10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*		13
10 × 3½ × ·54 *28·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 3½ × 3½ × ·54 *45·30*		14
11 × 3½ × ·48 *33·05*	11 × 3½ × ·57 *36·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*53·60*		15
11 × 3½ × ·59 *37·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × 3½ × ·54 *45·30*	12 × 4 × 4 × ·58 *50·20*	*53·70*	*57·60*	15 × 4 × 4 × ·44 *62·15*	CHANNELS	16
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·64 *52·60*	*57·60*	15 × 4 × 4 × ·44 *62·15*				17
12 × 4 × 4 × ·58 *50·20*	*56·50*	15 × 4 × 4 × ·44 *62·15*						18
58·70	15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·60 *71·80*						19
15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·63 *73·60*	17 × 4 × 4 × ·50 *81·60*						20
76·00	17 × 4 × 4 × ·54 *84·60*							21
17 × 4 × 4 × ·58 *87·55*	17 × 4 × 4 × ·70 *96·35*							22
17 × 4 × 4 × ·75 *99·95*								23
								24

Section moduli above are given to nearest ·05

NOTES.—TABLE 40 *(concluded)*

(*b*) half the distance in feet from the mid-point of length as defined above to the top of the overflow.

3. Correction for spacing. Where the spacing of the stiffeners differs from 24 inches, the modulus is to be modified in direct proportion.

4. Welded construction. When the bulkhead plating, boundaries, stiffeners and end brackets are welded and the stiffeners are not supported by horizontal girders, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

5. Riveted end attachments are to be in accordance with the requirements of Table 36.

6. Particulars of sections and moduli are given in Table 56.

TABLE 41 HORIZONTAL GIRDERS IN OIL FUEL BUNKERS

NUMERAL	GIRDER		NUMERAL	GIRDER		NUMERAL	GIRDER	
	WEB PLATE	FACE AREA		WEB PLATE	FACE AREA		WEB PLATE	FACE AREA
	Inches	Square inches		Inches	Square inches		Inches	Square inches
50	12 × ·34	1·3	500	34 × ·42	6·2	950	48 × ·46	9·8
100	16 × ·34	2·1	550	36 × ·42	6·6	1000	48 × ·46	10·7
150	19 × ·34	2·9	600	37 × ·44	7·4	1100	49 × ·46	12·0
200	22 × ·36	3·5	650	39 × ·44	7·7	1200	52 × ·46	12·0
250	24 × ·36	4·0	700	41 × ·46	8·0	1300	54 × ·48	12·0
300	27 × ·36	4·0	750	43 × ·46	8·3	1400	57 × ·50	12·0
350	29 × ·38	4·5	800	45 × ·46	8·5	1500	60 × ·50	12·0
400	31 × ·38	4·9	850	47 × ·46	8·5			
450	33 × ·40	5·1	900	48 × ·46	8·9			

NOTES.—TABLE 41

1. Numeral $= \frac{s^2 \times d \times H}{100}$

where s = length, in feet, between centres of end brackets.

d = depth, in feet, between the centres of the two adjacent spans of stiffeners or frames supported by the girder.

H = the greater of the two following values :—

(*a*) the distance, in feet, from the girder to the top of the tank.

(*b*) half the distance, in feet, from the girder to the top of the overflow.

2. For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

3. The face area of girders derived from the Table may take the form of rolled sections, flanged girder plates or welded face plates, the width of the girder being the extreme width of the web plate.

4. For end connections and constructional details *see* D 2006 to D 2010.

A—RIVETED

BREADTH OF HATCHWAY	WEB PLATE — BEAM SPACING CENTRE TO CENTRE				DOUBLE ANGLES ON EDGES OF BEAMS
	Feet 4	Feet 5	Feet 6	Feet 7	
Feet	INCHES *Modulus—Inches³*				Inches
10	*15*	*20*	11 × ·30 *42*	11½ × ·32 *45*	3 × 3 × ·40
12	10 × ·38 B.P. *26*	10 × ·44 B.P. *28*	12 × ·32 *48*	13 × ·34 *54*	3 × 3 × ·40
14	10 × ·46 B.P *29*	12 × ·32 *50*	14 × ·34 *64*	15½ × ·36 *72*	3 × 3 × ·42
16	12 × ·32 *54*	14 × ·34 *68*	16 × ·36 *82*	17½ × ·38 *93*	3½ × 3 × ·42
18	14 × ·34 *76*	16 × ·36 *91*	18 × ·36 *107*	19½ × ·38 *120*	4 × 3 × ·44
20	15 × ·34 *83*	18 × ·36 *107*	20 × ·38 *124*	22 × ·38 *141*	4 × 3 × ·44
22	16 × ·36 *100*	19 × ·36 *126*	22 × ·38 *154*	24 × ·40 *170*	4 × 3 × ·50
24	17 × ·36 *120*	20 × ·38 *150*	23 × ·40 *182*	25½ × ·42 *210*	5 × 3½ × ·46
26	18 × ·36 *142*	21 × ·38 *175*	24 × ·40 *210*	26½ × ·42 *241*	5 × 3½ × ·52
28	19 × ·38 *167*	22 × ·38 *202*	25 × ·40 *240*	28 × ·42 *280*	6 × 3½ × ·50
30	20 × ·38 *184*	23 × ·40 *222*	26 × ·42 *261*	29 × ·44 *303*	6 × 3½ × ·52

B—RIVETED

10	7 × ·36 B.P. *11*	*15*	*17*	*20*	3 × 3 × ·40
12	*15*	*20*	*24*	*32*	3 × 3 × ·40
14	*20*	10 × ·38 B.P. *26*	11 × ·30 *44*	12 × ·32 *50*	3 × 3 × ·42
16	11 × ·30 *48*	11 × ·30 *48*	12 × ·32 *54*	13½ × ·34 *64*	3½ × 3 × ·42
18	11 × ·30 *54*	12 × ·32 *61*	14 × ·34 *76*	15½ × ·36 *87*	4 × 3 × ·44
20	12 × ·32 *61*	13 × ·34 *69*	16 × ·36 *91*	17½ × ·36 *103*	4 × 3 × ·44
22	12½ × ·32 *71*	14 × ·34 *83*	17 × ·36 *109*	18½ × ·38 *123*	4 × 3 × ·50
24	13 × ·34 *84*	14½ × ·34 *97*	18 × ·36 *128*	19½ × ·38 *145*	5 × 3½ × ·46
26	13½ × ·34 *97*	15 × ·34 *112*	19 × ·38 *154*	20½ × ·38 *170*	5 × 3½ × ·52
28	14 × ·34 *112*	16 × ·36 *133*	20 × ·38 *179*	21½ × ·38 *196*	6 × 3½ × ·50
30	15 × ·34 *126*	17 × ·36 *149*	21 × ·38 *196*	22½ × ·38 *214*	6 × 3½ × ·52

For notes see page 158

TABLE 43 C — HATCHWAY BEAMS

C—WELDED

DEPTH OF BEAM OVER FACE PLATES	BASIC WEB THICKNESS	* CORRECTION TO MODULUS PER ·05 INCH VARIATION IN WEB THICKNESS	BASIC FLANGE THICKNESS	† CORRECTION TO MODULUS PER ·10 INCH VARIATION IN FLANGE THICKNESS	AREA OF EACH FACE PLATE SQUARE INCHES.									
					3	4	5	6	7	8	9	10	11	12
					MODULUS									
Inches	Inches	Inches³	Inches	Inches³	← Inches³ →									
8	·35	·5	·60	1·0	23	30	36							
10	·35	·5	·60	1·0	30	39	48							
12	·40	1·0	·70	1·5		49	60	70						
14	·40	1·5	·70	1·5		60	73	85	98					
16	·45	2·0	·80	2·0			86	101	115	130				
18	·45	2·5	·80	2·0			101	117	133	150	166			
20	·50	3·0	·90	2·5				134	153	171	190	207		
22	·50	3·5	·90	3·0				152	173	193	213	233	254	
24	·55	4·0	1·0	3·5					195	217	239	261	283	305

*When the thickness of the web is increased the modulus is to be increased by the appropriate correction
†When the thickness of the flange is increased, the modulus is to be reduced by the appropriate correction

NOTES.—TABLE 43

1. **Scantlings** of riveted hatchway beams are to be determined from the Table as follows :—

For hatchways requiring coamings 24 inches in height (D2301 to D 2302), in ships 200 feet or more in length ... ... A

in ships 100 feet or less in length ... ... B

(For intermediate lengths scantlings are to be determined by interpolation.)

For hatchways requiring coamings 18 inches in height, or less, except in cargo spaces ... ... B

For hatchways in cargo spaces (*see also* note 4) ... A

For hatchways in accommodation spaces ... ... B

2. The Table depth of hatchway beams is to be measured at mid-length from the top of the upper mounting angles to the bottom of the lower mounting angles or bulb plate. The depth of the ends may be half that at the centre but is not to be less than 6 inches. Alternative arrangements may be adopted if suitable strength is provided at the ends of the webs. The larger flange of the mountings is to be fitted horizontally.

3. Scantlings of welded hatchway beams may be obtained from C on the basis of modulus equivalent to the requirements of A or B. The width of the face plates is to be sufficient to provide the minimum hatch bearing surface required by D 2312.

4. Where the 'tween deck height in cargo spaces and trunked hatchways (*see* D 2329) exceeds 8 feet 6 inches the modulus of the hatchway beams is to be increased in direct proportion.

5. For construction details *see* D 2309 to D 2315. For riveting and welding *see* Table 52 H.

DIAMETER OF RUDDER HEADS TABLE 44

NUMERAL	SEA SPEED IN KNOTS						
	10 and below	12	14	16	18	20	22
	DIAMETER OF RUDDER HEAD						
	Inches	Inches	Inches	Inches	Inches	Inches	Inches
30	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$			
40	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$			
50	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$			
60	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{2}$			
70	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{3}{4}$			
80	5	$5\frac{1}{4}$	$5\frac{1}{2}$	6			
90	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$		
100	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$		
120	6	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$	$7\frac{3}{4}$		
140	$6\frac{1}{4}$	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	
160	$6\frac{3}{4}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	
190	$7\frac{1}{4}$	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	
220	$7\frac{3}{4}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{3}{4}$
260	$8\frac{1}{4}$	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{1}{2}$	$11\frac{1}{4}$
300	$8\frac{1}{2}$	$8\frac{3}{4}$	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{2}$	11	$11\frac{3}{4}$
350	9	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{4}$	11	$11\frac{1}{2}$	$12\frac{1}{4}$
400	$9\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{4}$	$10\frac{3}{4}$	$11\frac{1}{2}$	12	13
450	10	10	$10\frac{1}{2}$	11	12	$12\frac{1}{2}$	$13\frac{1}{2}$
510	$10\frac{1}{2}$	$10\frac{1}{2}$	11	$11\frac{1}{2}$	$12\frac{1}{2}$	13	14
570	11	11	$11\frac{1}{2}$	12	13	$13\frac{1}{2}$	$14\frac{3}{4}$
640	$11\frac{1}{2}$	$11\frac{1}{2}$	12	$12\frac{1}{2}$	$13\frac{1}{2}$	$14\frac{1}{4}$	$15\frac{1}{2}$
720	12	12	$12\frac{1}{2}$	13	14	15	16
800	$12\frac{1}{2}$	$12\frac{1}{2}$	13	$13\frac{1}{2}$	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$
890	13	13	$13\frac{1}{2}$	14	15	16	17
980	$13\frac{1}{2}$	$13\frac{1}{2}$	14	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$
1080	14	14	$14\frac{1}{2}$	$15\frac{1}{4}$	$16\frac{1}{4}$	$17\frac{1}{4}$	$18\frac{1}{4}$
1180	$14\frac{1}{2}$	$14\frac{1}{2}$	15	16	17	18	19
1290	15	15	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$	$18\frac{1}{2}$	$19\frac{1}{2}$
1400	$15\frac{1}{2}$	$15\frac{1}{2}$	16	17	18	19	20

NOTES.—TABLE 44

1. Numeral.—(*a*) The numeral = A × D where :

A = total area of rudder in square feet, including balanced portion, if any.

D = distance in feet of centre of gravity of area A from the centre line of the pintles.

(*b*) For balanced rudders the numeral is not to be less than 80 per cent of that derived from the part of the rudder abaft the centre line of the pintles.

2. For rudders strengthened for Navigation in ice *see* D 1009.

3. Where steel complying with P 1010 or scrap material (*see* D 2603) is used the diameter of rudder head is to be increased by 5 per cent.

TABLE 45

SINGLE PLATE RUDDERS

DIAMETER OF RUDDER HEAD, TABLE 44	ARMS—SPACED 48 INCHES BETWEEN CENTRES				PLATE	DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	BREADTH	THICKNESS				
		AT MAINPIECE	ROUND MAINPIECE	AT END		
Inches	Inches	Inches	Inches	Inches	Inches	Inches
3	3	2	$1\frac{3}{8}$	$\frac{3}{4}$	·78	$\frac{7}{8}$
4	4	$2\frac{3}{8}$	$1\frac{3}{4}$	$\frac{7}{8}$	·80	1
5	5	$2\frac{3}{4}$	$2\frac{1}{8}$	1	·82	$1\frac{1}{8}$
6	$5\frac{1}{2}$	$3\frac{1}{8}$	$2\frac{1}{4}$	1	·84	$1\frac{1}{8}$
7	6	$3\frac{5}{8}$	$2\frac{1}{2}$	1	·86	$1\frac{1}{8}$
8	$6\frac{1}{2}$	4	$2\frac{3}{4}$	1	·88	$1\frac{1}{4}$
9	7	$4\frac{1}{4}$	3	1	·90	$1\frac{1}{4}$
10	$7\frac{1}{2}$	$4\frac{5}{8}$	$3\frac{1}{4}$	$1\frac{1}{8}$	·92	$1\frac{1}{4}$
11	8	5	$3\frac{1}{2}$	$1\frac{1}{8}$	·94	$1\frac{1}{4}$
12	$8\frac{1}{2}$	$5\frac{3}{8}$	$3\frac{5}{8}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
13	$8\frac{3}{4}$	$5\frac{3}{4}$	$3\frac{3}{4}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
14	9	6	$3\frac{7}{8}$	$1\frac{1}{8}$	·98	$1\frac{1}{4}$
15	$9\frac{1}{4}$	$6\frac{1}{4}$	4	$1\frac{1}{8}$	·98	$1\frac{1}{4}$

NOTES.—TABLE 45

Corrections for spacing of arms.—The breadth of the arms is to be modified directly as the spacing.

The thickness of the plate is to be modified with the spacing at the rate of ·01 inch for every inch increase or reduction from 48 inches.

DOUBLE PLATE RUDDERS

SIDE PLATES

DIAMETER OF RUDDER HEAD TABLE 44	SPACING OF ARMS BETWEEN CENTRES INCHES			SOLID FRAMES
	FORGED & CAST FRAMES			DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	36	48	60	
	PLATE FRAMES			
	24	36	48	
Inches	Inches	Inches	Inches	Inches
4	·32	·40		¾
5	·34	·40		¾
6	·36	·42		⅞
7	·36	·44	·50	⅞
8	·38	·46	·52	⅞
9	·38	·46	·54	⅞
10	·40	·48	·56	1
11	·40	·48	·58	1
12	·42	·50	·60	1
13	·42	·50	·60	1
14	·44	·52	·62	1
15	·44	·52	·62	1

NOTES.—TABLE 46

1. Plate thickness.—When the ratio of the fore and aft dimension to the vertical dimension of the unsupported panels of plating exceeds 3:2 an additional vertical diaphragm is to be fitted.

The thickness of side plates of rudder with a plate frame may require to be increased in way of the vertical webs which replace the mainpiece.

2. Plate frames.—Horizontal webs and vertical webs not replacing the mainpiece are to have the same thickness as the side plates, but the plates forming the top and bottom of the rudder are to be of increased thickness.

Vertical webs replacing the mainpiece are to have a thickness equal to twice the Table thickness of side plates for 36 inches spacing.

TABLE 47 RUDDER PINTLES

ONE OR TWO PINTLES

BALANCED OR UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS					
	12 and below	14	16	18	20	22
	DIAMETER OF PINTLES					
Square feet	Inches	Inches	Inches	Inches	Inches	Inches
10	3·0	3·4	3·8			
20	4·2	4·7	5·2			
40	6·0	6·2	6·6	7·4	8·2	
60	7·4	7·4	7·8	8·6	9·6	
80	8·0	8·0	8·4	9·2	10·4	11·8
100		8·6	9·0	9·8	11·0	12·8
120		9·2	9·6	10·6	12·0	13·8
140		9·8	10·2	11·4	12·8	14·8
160			11·0	12·2	13·6	15·8
180			11·8	13·0	14·8	17·0
200			12·6	13·8	15·8	18·0

THREE OR MORE PINTLES

UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS				
	12 and below	14	16	18	20
	DIAMETER OF PINTLES				
Square feet	Inches	Inches	Inches	Inches	Inches
10	2·4	2·8	3·2		
20	3·8	4·2	4·6		
30	5·0	5·4	5·8		
40	6·0	6·2	6·6	7·4	
50	6·8	6·9	7·2	8·0	
60	7·4	7·4	7·8	8·6	9·6

NOTES.—TABLE 47

1. **Area supported.**—When there is one pintle only the area supported is that below a horizontal line half way between the pintle and the top of the rudder.

Where there are two pintles the areas supported are those bounded by a horizontal line midway between the two pintles.

Where there are more than two pintles the area supported is to be taken as the total area of the rudder divided by the number of pintles.

2. **Pintles.**—The diameter of pintles obtained from the Table is to be measured outside the liner, if fitted.

The bearing length, except that of the bottom pintle, is to be 20 per cent greater than the diameter. The bearing length of the bottom pintle is to be equal to the diameter of the pintle.

The length of pintle housing in the rudder gudgeons is to be 20 per cent greater than the diameter of the pintle.

Pintles are to be fitted as taper bolts, the taper not being greater than 1 in 12 on the radius.

DIAMETER OF RUDDER HEAD TABLE 44	HORIZONTAL COUPLING		VERTICAL COUPLING		SCARPHED COUPLING					
	6 BOLTS		8 BOLTS			WIDTH OF SCARPHS		BOLTS		
	MEAN DISTANCE OF CENTRES OF BOLTS FROM CENTRE OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	WIDTH OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	LENGTH OF SCARPH	AT TOP	AT BOTTOM	NUMBER		DIAMETER
								TOTAL	IN TOP ROW	
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches			Inches
$3\frac{1}{2}$	4	$1\frac{1}{8}$								
$3\frac{3}{4}$	4	$1\frac{1}{8}$								
4	$4\frac{1}{4}$	$1\frac{1}{4}$								
$4\frac{1}{4}$	$4\frac{1}{4}$	$1\frac{1}{4}$								
$4\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$4\frac{3}{4}$	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
5	$4\frac{1}{2}$	$1\frac{3}{8}$	12	$1\frac{3}{8}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$5\frac{1}{4}$	$4\frac{3}{4}$	$1\frac{1}{2}$	12	$1\frac{1}{2}$	$13\frac{1}{2}$	9	15	6	2	$1\frac{1}{2}$
$5\frac{1}{2}$	5	$1\frac{1}{2}$	$12\frac{1}{2}$	$1\frac{1}{2}$	14	$9\frac{1}{2}$	$15\frac{1}{2}$	6	2	$1\frac{5}{8}$
$5\frac{3}{4}$	$5\frac{1}{4}$	$1\frac{1}{2}$	13	$1\frac{1}{2}$	$14\frac{1}{2}$	10	16	6	2	$1\frac{3}{4}$
6	$5\frac{1}{2}$	$1\frac{5}{8}$	$13\frac{1}{2}$	$1\frac{5}{8}$	15	$10\frac{1}{2}$	$16\frac{1}{2}$	6	2	$1\frac{7}{8}$
$6\frac{1}{4}$	$5\frac{3}{4}$	$1\frac{3}{4}$	14	$1\frac{3}{4}$	$15\frac{3}{4}$	11	$17\frac{1}{4}$	6	2	2
$6\frac{1}{2}$	6	$1\frac{7}{8}$	$14\frac{1}{2}$	$1\frac{7}{8}$	$16\frac{1}{4}$	$11\frac{1}{2}$	18	6	2	$2\frac{1}{8}$
$6\frac{3}{4}$	$6\frac{1}{4}$	$1\frac{7}{8}$	15	$1\frac{7}{8}$	17	12	$18\frac{3}{4}$	6	2	$2\frac{1}{8}$
7	$6\frac{1}{2}$	2	$15\frac{3}{4}$	2	$17\frac{1}{2}$	$12\frac{1}{4}$	$19\frac{1}{2}$	6	2	$2\frac{1}{4}$
$7\frac{1}{4}$	$6\frac{3}{4}$	$2\frac{1}{8}$	$16\frac{1}{4}$	$2\frac{1}{8}$	18	$12\frac{3}{4}$	20	6	2	$2\frac{1}{4}$
$7\frac{1}{2}$	7	$2\frac{1}{8}$	$16\frac{3}{4}$	$2\frac{1}{8}$	$18\frac{3}{4}$	$13\frac{1}{4}$	21	7	2	$2\frac{1}{8}$
$7\frac{3}{4}$	$7\frac{1}{4}$	$2\frac{1}{4}$	$17\frac{1}{4}$	$2\frac{1}{4}$	$19\frac{1}{2}$	$13\frac{1}{2}$	$21\frac{1}{2}$	7	2	$2\frac{1}{8}$
8	$7\frac{1}{2}$	$2\frac{3}{8}$	18	$2\frac{3}{8}$	20	14	22	7	2	$2\frac{1}{4}$
$8\frac{1}{2}$	$7\frac{3}{4}$	$2\frac{1}{2}$	19	$2\frac{1}{2}$	$21\frac{1}{4}$	15	24	7	2	$2\frac{1}{2}$
9	$8\frac{1}{4}$	$2\frac{3}{4}$	20	$2\frac{3}{4}$	$22\frac{1}{2}$	$15\frac{3}{4}$	25	7	2	$2\frac{5}{8}$
$9\frac{1}{2}$	$8\frac{1}{2}$	$2\frac{7}{8}$	$21\frac{1}{4}$	$2\frac{7}{8}$	$23\frac{3}{4}$	$16\frac{3}{4}$	26	7	2	$2\frac{3}{4}$
10	9	3	$22\frac{1}{2}$	3	25	$17\frac{1}{2}$	$27\frac{1}{2}$	7	2	$2\frac{7}{8}$
$10\frac{1}{2}$	$9\frac{1}{2}$	$3\frac{1}{8}$	$23\frac{1}{2}$	$3\frac{1}{8}$	$26\frac{1}{4}$	$18\frac{1}{2}$	29	8	2	$2\frac{7}{8}$
11	10	$3\frac{1}{4}$	$24\frac{3}{4}$	$3\frac{1}{4}$	$27\frac{1}{2}$	$19\frac{1}{4}$	30	8	2	3
$11\frac{1}{2}$	$10\frac{1}{2}$	$3\frac{3}{8}$	26	$3\frac{3}{8}$	$28\frac{3}{4}$	$20\frac{1}{4}$	$31\frac{1}{2}$	8	2	$3\frac{1}{8}$
12	$10\frac{3}{4}$	$3\frac{1}{2}$	27	$3\frac{1}{2}$	30	21	33	8	2	$3\frac{1}{4}$
$12\frac{1}{2}$	$11\frac{1}{4}$	$3\frac{5}{8}$	28	$3\frac{5}{8}$	$31\frac{1}{4}$	25	$34\frac{1}{2}$	9	3	$3\frac{1}{4}$
13	$11\frac{3}{4}$	$3\frac{3}{4}$	29	$3\frac{3}{4}$	$32\frac{1}{2}$	26	36	9	3	$3\frac{1}{4}$
$13\frac{1}{2}$	$12\frac{1}{4}$	$3\frac{7}{8}$	30	$3\frac{7}{8}$	$33\frac{3}{4}$	27	$37\frac{1}{2}$	9	3	$3\frac{3}{8}$
14	$12\frac{3}{4}$	4	$31\frac{1}{2}$	4	35	28	39	9	3	$3\frac{5}{8}$
$14\frac{1}{2}$	13	$4\frac{1}{8}$	$32\frac{1}{2}$	$4\frac{1}{8}$	$36\frac{1}{4}$	29	40	9	3	$3\frac{3}{4}$
15	$13\frac{1}{2}$	$4\frac{1}{4}$	$33\frac{1}{2}$	$4\frac{1}{4}$	$37\frac{1}{2}$	30	41	9	3	$3\frac{7}{8}$

NOTES.—TABLE 48

1. The width of material in the flanges, or palms of scarphs, outside the bolt holes is not to be less than two thirds of the diameter of the bolt.

2. In scarphed couplings the athwartship dimension at the top of the scarph is not to be less than the diameter of the rudder head. The thickness of the tips of the palms is not to be less than thirteen per cent of the diameter of the rudder head.

TABLE 49 STEERING CHAINS, RODS, QUADRANTS AND TILLERS

DIAMETER OF RUDDER HEAD TABLE 44	DIAMETER OF WROUGHT IRON CHAINS	DIAMETER OF RODS	RADIUS OF QUADRANT	BOSS OF QUADRANT		QUADRANTS AND TILLERS		
				Depth	Outside diameter	Sizes of arms at twice the diameter of rudder head from centre of rudder head		
						One arm	Two arms	Three arms
Inches	Inches	Inches	Feet Inches	Inches	Inches	Inches	Inches	Inches
3½	9/16	5/8	3 – 2	3½	6¼	3½ × 2½		
3¾	9/16	5/8	3 – 3	3¾	6¾	4 × 2½		
4	5/8	11/16	3 – 4	4	7¼	4¼ × 2½		
4¼	11/16	3/4	3 – 5	4¼	7½	4½ × 2¾		
4½	11/16	3/4	3 – 6	4½	8	5 × 2¾	3¾ × 2¼	
4¾	3/4	13/16	3 – 7	4¾	8½	5¼ × 2¾	4 × 2¼	
5	3/4	13/16	3 – 8	5	9	5½ × 3	4¼ × 2½	
5¼	13/16	7/8	3 – 9	5¼	9¼	5¾ × 3	4½ × 2½	
5½	13/16	15/16	3 – 10	5½	9¾	6 × 3¼	4¾ × 2½	
5¾	7/8	15/16	3 – 11	5¾	10¼	6¼ × 3¼	5 × 2½	
6	7/8	1	4 – 0	6	10¾	6½ × 3½	5¼ × 2¾	
6¼	15/16	1 1/16	4 – 1	6¼	11¼	6¾ × 3½	5½ × 2¾	
6½	15/16	1 1/16	4 – 2	6½	11¾	7 × 3¾	5½ × 3	
6¾	1	1⅛	4 – 3	6¾	12	7¼ × 3¾	5¾ × 3	
7	1	1¼	4 – 4	7	12½	7½ × 4	6 × 3¼	
7¼	1 1/16	1¼	4 – 5	7¼	13	7¾ × 4¼	6 × 3¼	
7½	1 1/16	1 5/16	4 – 6	7½	13½	8 × 4½	6¼ × 3½	
7¾	1⅛	1⅜	4 – 7	7¾	14	8¼ × 4½	6¼ × 3¾	
8	1 3/16	1⅜	4 – 8	8	14½	8½ × 4¾	6½ × 4	5¾ × 3½
8½	1¼	1½	5 – 0	8½	15¼	9 × 5	7 × 4	6 × 3¾
9	1 5/16	1 9/16	5 – 4	9	16¼	9½ × 5¼	7½ × 4¼	6½ × 3¾
9½	1⅜	1 11/16	5 – 8	9½	17	10 × 5¾	8 × 4½	7 × 4
10	1 7/16	1¾	6 – 0	10	18	10½ × 6	8½ × 4½	7½ × 4
10½	1½	1⅞	6 – 4	10½	19	11 × 6¼	9 × 4¾	8 × 4
11	1 9/16	1 15/16	6 – 8	11	19¾	11½ × 6¾	9½ × 5	8½ × 4½
11½	1⅝	1 15/16	7 – 0	11½	20¾	12 × 7	10 × 5¼	8½ × 5
12	1⅝	2	7 – 4	12	21½	12½ × 7½	10½ × 5½	9 × 5
12½			7 – 8	12½	22½	13 × 7½	11 × 5½	9½ × 5
13			8 – 0	13	23½	13½ × 7½	11¼ × 5¾	10 × 5
13½			8 – 0	13½	24½	14 × 8	11½ × 6	10 × 5¼
14			8 – 0	14	25¼	14½ × 8	12 × 6	10½ × 5¼
14½			8 – 0	14½	26¼	15 × 8½	12¼ × 6½	10½ × 5½
15			8 – 0	15	27	15½ × 8½	12¾ × 6½	11 × 5½

BOLTS FOR BOLTED TILLERS AND QUADRANTS TABLE 50

DIAMETER OF RUDDER HEAD TABLE 44	ONE BOLT EACH SIDE		TWO BOLTS EACH SIDE		FOUR BOLTS EACH SIDE			THICKNESS OF COUPLING
	Diameter	Distance centre to centre	Diameter	Distance centre to centre	Diameter	Inner bolts centre to centre	Outer bolts centre to centre	
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
3½	1½	11	1¼	10	¾	8½	13½	1
4	1¾	12	1⅜	11	⅞	9½	15	1½
4½	2	13	1½	12	1	10½	16½	1⅝
5	2¼	14	1¾	13	1⅛	11½	18	1¾
5½	2½	15	1⅞	14	1¼	12½	20	1⅞
6	2¾	16½	2	15	1⅜	13½	22	2
6½	3	18	2⅛	16	1½	15	24	2
7	3¼	19	2¼	17	1⅝	16	25½	2¼
7½	3½	20½	2½	18½	1¾	17	27½	2¼
8	3¾	22	2⅝	20	1⅞	18½	29½	2½
8½	3⅞	23	2¾	21	2	19½	31½	2½
9	4	24	2⅞	22	2⅛	20½	33½	2¾
9½			3	23½	2⅛	21½	34½	2¾
10			3¼	24½	2¼	22½	36	3
10½			3⅜	26	2⅜	24	38	3
11			3⅝	27	2½	25	40	3
11½			3¾	28½	2⅝	26	42	3
12			3⅞	29½	2¾	27	43½	3¼
13			4¼	32	3	29½	47½	3¼
14			4½	34½	3⅛	32	51	3¼
15			4⅞	37	3⅜	34	54	3¼

TABLE 51 MASTS AND DERRICK POSTS

DIAMETER AND THICKNESS AT DECK

STAYED

LENGTH OF MAST OR POST	NO DERRICKS	WORKING LOAD OF DERRICKS	
		4 TONS	8 TONS
Feet	Inches	Inches	Inches
30	12 × ·24	18 × ·30	20 × ·30
35	14 × ·26	20 × ·30	22 × ·32
40	16 × ·28	22 × ·30	24 × ·34
45	18 × ·30	23 × ·32	25 × ·36
50	20 × ·32	24 × ·34	26 × ·38
55	22 × ·34	26 × ·38	28 × ·40
60	24 × ·36	28 × ·40	30 × ·42

UNSTAYED

LENGTH OF MAST OR POST	WORKING LOAD OF DERRICKS	
	4 TONS	8 TONS
Feet	Inches	Inches
20	24 × ·36	24 × ·60
25	26 × ·38	26 × ·66
30	28 × ·40	28 × ·72
35	30 × ·40	30 × ·72

NOTES.—TABLE 51

1. Length of mast or derrick post is to be measured from deck to hounds. Tops of small mast houses and derrick plates are not to be regarded as the deck for this purpose, unless the structure is adequately strengthened.

2. Working load of derricks is defined in D 2801 to D 2802.

3. The diameter and thickness of masts and derrick posts at the hounds are to be 85 per cent of the scantlings at the deck.

A

DIAMETER AND SPACING OF RIVETS AND BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

THICKNESS OF PLATES:—	Inches Not exceeding ·36	Inches above ·36 and not exceeding ·50	Inches above ·50 and not exceeding ·72	Inches above ·72 and not exceeding ·94	Inches above ·94 and not exceeding 1·14	Inches above 1·14 and not exceeding 1·26
DIAMETER OF RIVETS:—	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
SPACING IN DIAMETERS.	SPACING IN INCHES					
$3\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	4	$4\frac{3}{8}$
4	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
$4\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{8}$	4	$4\frac{1}{2}$	5	$5\frac{5}{8}$
5	$3\frac{1}{8}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5	$5\frac{5}{8}$	$6\frac{1}{4}$
$5\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{8}$	$4\frac{7}{8}$	$5\frac{1}{2}$	$6\frac{1}{8}$	—
6	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	—
$6\frac{1}{2}$	4	$4\frac{7}{8}$	$5\frac{3}{4}$	$6\frac{1}{2}$	—	—
7	$4\frac{1}{2}$	$5\frac{1}{4}$	$6\frac{1}{8}$	7	—	—

BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

		Inches	Inches	Inches	Inches	Inches	Inches
END LAPS	Single riveted ...	$2\frac{1}{2}$	3	—	—	—	—
	Double riveted ...	$4\frac{1}{4}$	5	6	—	—	—
	Treble riveted ...	6	$7\frac{1}{2}$	9	$10\frac{1}{2}$	12	$13\frac{1}{2}$
	Quadruple riveted ...	—	—	12	14	16	18
	Quintuple riveted ...	—	—	15	$17\frac{1}{2}$	20	$22\frac{1}{2}$
BUTT STRAPS*	Single riveted ...	$4\frac{1}{2}$	$5\frac{1}{4}$	—	—	—	—
	Double riveted ...	8	$9\frac{3}{4}$	$11\frac{1}{4}$	—	—	—
	Treble riveted ...	—	$14\frac{1}{4}$	$16\frac{3}{4}$	19	$21\frac{1}{2}$	24
	Quadruple riveted ...	—	—	22	25	$28\frac{1}{4}$	$31\frac{1}{2}$
SEAMS	Single riveted ...	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	—	—
	Double riveted ...	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	$7\frac{1}{2}$
	Treble riveted ...	—	—	—	$8\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{2}$

* Single butt straps are to be 25 per cent thicker than the plates to be connected. Where double butt straps are fitted the thickness of the countersunk strap is to be 70 per cent and the thickness of the strap on the opposite side is to be 60 per cent of the thickness of the plates to be connected.

NOTES.—TABLE 52 A

1. The diameter of rivets in seams of keel, sheerstrake, deckstringer, middle line strake of inner bottom and margin plate is to be regulated by the thickness of the adjacent plating.

2. Rivets are to be kept sufficiently clear of edges of plating and of each other, and the distance from the centre of rivet holes to the edges of the plating, end laps or butt straps is not to be less than one and a half rivet diameters.

3. The distance between the centres of consecutive rows of rivets is to be three and a half diameters in end laps, three diameters in butt straps and two and a half diameters in seams.

TABLE 52 B — RIVETING AND WELDING

B

END LAPS AND SEAMS OF SHELL PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth. End laps	Breadth. Butt strap	Spacing of rivets centre to centre	Type of seam	Breadth
	Inches	Inches	Inches		Inches	Inches	Inches		Inches
Sheerstrake for ·4L amidships. *See* Note 4. Bottom plating from keel to upper turn of bilge for ·4L amidships. Keel plates. *See* Note 4. Boss plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$	Double	6
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Sheerstrake at ends. Bottom plating from keel to upper turn of bilge at ends.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4	Double	6
Side plating from upper turn of bilge to sheerstrake.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quadruple	14	25	4	Treble	$8\frac{1}{2}$
	·94	1·04	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Treble	$9\frac{1}{2}$

NOTES.—TABLE 52 B

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships. (Except as covered by notes 7 and 8.)

3. Seams of side plating in all ships exceeding 275 feet in length are to be not less than double riveted. (Except as covered by note 8.)

4. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating. (Except as covered by note 8.)

5. For number of rivets between frames in seams of shell plating *see* Table 52 E. Where the form of the ship, forward and aft, is curved the spacing of the rivets is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 500 feet *see* note 7.) Where longitudinal framing is adopted the spacing of rivets in seams of shell plating is not to exceed $4\frac{1}{2}$ diameters, or 4 diameters in way of the strengthening of bottom forward.

6. For riveting in way of strengthening of bottom forward *see* D 808. For riveting in oil fuel bunkers *see* Table 52 H. For riveting in way of strengthening for navigation in ice *see* D 1006.

7. In ships above 500 feet in length in the three seams nearest to the neutral axis and for one-fourth of the ship's length in the forward and after bodies the following additions are to be made :—

Above 500 feet and not exceeding 525 feet an additional pair of rivets is to be fitted in each frame space.

Above 525 feet and not exceeding 550 feet two additional pairs of rivets are to be fitted in each frame space.

Above 550 feet and not exceeding 600 feet one seam, and in ships exceeding 600 feet two seams, are to be treble riveted, two additional pairs of rivets being fitted in each frame space in the other seam or seams.

In all the above ships one additional pair of rivets only need be fitted in way of 27 inch frame spacing.

8. In ships where the draught does not exceed ·7D (D being measured to the uppermost continuous deck) and the riveting required by Table 19 for the strength deck stringer angle is single, the lower edge of the sheerstrake may also be single riveted.

9. Seams of long bridges may be single riveted where the riveting required by Table 19 is single but are to be double riveted for four frame spaces at the ends.

10. Seams of poops, short bridges and forecastles may be single riveted.

11. In single riveted seams the rivet is to pass through the frame. In double riveted seams one frame rivet (that adjacent to the caulking edge) is to pass through the seams at each frame except where the frames or edges of the plating are joggled when both rivets are to pass through the frame. In treble riveted seams two frame rivets, the upper and the lower, are to pass through the seams at each frame.

TABLE 52 C

END LAPS AND SEAMS OF DECK PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Inches	Inches	Inches		Inches	Inches	Inches		Inches.
Strength deck stringer plates for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	*See* note 2	
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3		
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$		
	·72	·84	1	Quadruple	14	25	4		
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$		
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5		
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Strength deck stringer plates at ends. Lower deck stringer plates. Deck tie plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$	*See* note 2	
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$		
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	4		
	·72	·94	1	Quadruple	14	25	$4\frac{1}{2}$		
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	5		
	1·14	1·26	$1\frac{1}{4}$	Quadruple	18	$31\frac{1}{2}$	$5\frac{5}{8}$		
Strength deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Single	3
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Single	3
	·72	·76	1	Quadruple	14	25	4	Single	$3\frac{1}{2}$
	·76	·94	1	Quadruple	14	25	4	Double	6
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Double	$6\frac{3}{4}$
Lower deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3
Deck plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	4	Single	3
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3

NOTES.—TABLE 52 C

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. In seams of stringer plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent deck plating.

3. For number of rivets between beams in seams of deck plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship, and in seams over deep tanks and oil cargo tanks, is not to exceed $4\frac{1}{2}$ diameters. Where longitudinal framing is adopted the spacing of rivets in seams of deck plating is not to exceed $4\frac{1}{2}$ diameters.

4. Where the riveting is not otherwise required to be increased the seams and butts of deck plating over oil fuel bunkers may be single riveted if not more than 28 feet below the top of the overflow; elsewhere the riveting is to be double.

5. For riveting of stringer angles on strength decks *see* Table 19. For riveting of stringer angles on lower decks *see* Table 52 F.

6. Butts of deck plating within line of openings need only be single riveted.

D
END LAPS AND SEAMS OF DOUBLE BOTTOMS

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Inches	Inches	Inches		Inches	Inches	Inches		Inches
Inner bottom middle line strake. Inner bottom plating for ·4L amidships. Margin plates. Centre and side girders (butts).		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4		
Inner bottom plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·42	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$

NOTES.—TABLE 52 D

1. In seams of middle line strake of inner bottom and margin plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent inner bottom plating.

2. Where oil fuel is carried in the double bottom and ceiling is not fitted completely over the inner bottom the seams and end laps are to be not less than double riveted.

3. For number of rivets between frames in seams of inner bottom plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed 4 diameters. Where longitudinal framing is adopted the spacing of rivets in seams of inner bottom plating is not to exceed 4 diameters.

TABLES 52 E AND F

E

NUMBER OF RIVETS IN SEAMS OF PLATING BETWEEN FRAMES AND BEAMS EXCLUDING RIVETS IN FRAMES AND BEAMS

FRAME OR BEAM SPACING	THICKNESS OF SHELL AND DECK PLATING IN INCHES						THICKNESS OF INNER BOTTOM PLATING IN INCHES		
	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94	Above ·94 and not exceeding 1·14	Above 1·14 and not exceeding 1·26	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72
	DIAMETER OF RIVET IN INCHES						DIAMETER OF RIVET IN INCHES		
	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
INCHES	NUMBER OF RIVETS IN EACH ROW						NUMBER OF RIVETS IN EACH ROW		
20	6	5					7	6	
$20\frac{1}{2}$	7	5					7	6	
21	7	5	5				7	6	5
$21\frac{1}{2}$	7	6	5				7	6	5
22	7	6	5				8	6	5
$22\frac{1}{2}$	7	6	5				8	6	5
23	7	6	5	5			8	7	6
$23\frac{1}{2}$		6	5	5			8	7	6
24		6	5	5			8	7	6
$24\frac{1}{2}$		6	5	5			9	7	6
25		7	6	5			9	7	6
$25\frac{1}{2}$		7	6	5				7	7
26		7	6	5	5			8	7
$26\frac{1}{2}$		7	6	5	5			8	7
27		7	6	5	5			8	7
$27\frac{1}{2}$		7	6	5	5			8	7
28		7	6	5	5	5		8	7
$28\frac{1}{2}$		8	6	6	5	5		8	7
29		8	7	6	5	5			8
$29\frac{1}{2}$		8	7	6	5	5			8
30		8	7	6	5	5			8
$30\frac{1}{2}$		8	7	6	5	5			8
31		9	7	6	5	5			8
$31\frac{1}{2}$			7	6	6	5			8
32			7	6	6	5			8
$32\frac{1}{2}$			7	6	6	5			8
33			8	7	6	5			9
$33\frac{1}{2}$			8	7	6	5			9
34			8	7	6	6			9
$34\frac{1}{2}$			8	7	6	6			9
35			8	7	6	6			9
$35\frac{1}{2}$			8	7	6	6			9
36			8	7	6	6			9

F

NUMBER OF RIVETS BETWEEN FRAMES IN EACH FLANGE OF THE ANGLES CONNECTING STRINGER PLATES TO SHELL AND INTERCOSTAL GIRDERS TO SHELL AND INNER BOTTOM

FRAME SPACING INCHES		DIAMETER OF RIVET IN INCHES			
		$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Above	Not exceeding	NUMBER OF RIVETS			
—	24	5	4	4	
24	27	6	5	5	4
27	30	7	6	5	5
30	33		7	6	5
33	36			7	6

For strength deck stringer angles *see* Table 19

TABLE 52 G

RIVETING AND WELDING

G

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATING THICKNESS	LEG LENGTH		
	Type 1	Type 2	Type 3
Inches	Inches	Inches	Inches
·20	·22	·18	·18
·30	·26	·20	·18
·40	·30	·24	·18
·50	·34	·28	·22
·60	·38	·32	·26

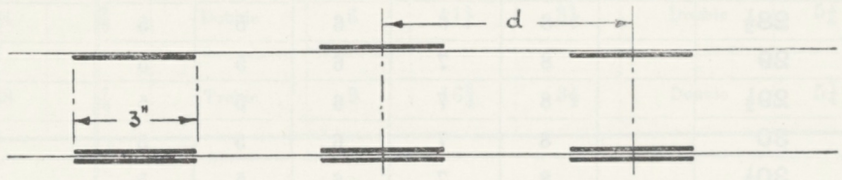
NOTES.—TABLE 52 G

1. **Size of fillet** is the minimum length of leg. The throat thickness of the weld is to be 70 per cent of the leg length.
2. **Leg length** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of the fillet will be specially considered.
3. Leg lengths for intermediate thicknesses to be obtained by direct interpolation.
4. **Minimum leg length** of fillet weld to be ·18 inch.

INTERMITTENT FILLET WELDS

STAGGERED INTERMITTENT (S)
Type 1

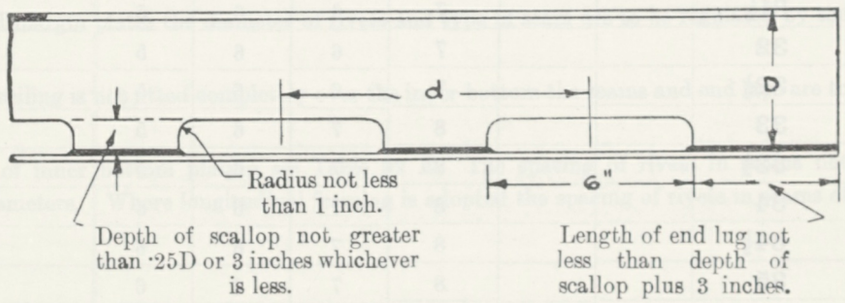
CHAIN INTERMITTENT (C)
Type 1



SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc. WITH DOUBLE FILLET WELDS

Type as per Table 52 H

Welding to be carried round the ends of all lugs



DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three and a half times for rivets 1 inch and above in diameter.

The distance from the centre of the rivet hole to the edge of the angle is to be not less than one and a half rivet diameters.

ITEM	RIVETED	WELDED				
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS			
			STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS	
		Type	S or C All Type 1	Distance (d) centre to centre	Type	Distance (d) centre to centre
				Inches		Inches
TRANSVERSE FRAMING						
Hold frames to shell — Spacing not over 29 inches	7		S	7	3	$9\frac{1}{2}$
„ over 29 inches and up to 32 inches	$6\frac{1}{2}$		S	$6\frac{1}{2}$	3	10
„ „ 32 „ „ „ 34 „	6		S	6	2	9
„ „ 34 „	$5\frac{1}{2}$		S	$5\frac{1}{2}$	2	9
in deep, oil fuel and peak tanks and in panting region (D 9)	$5\frac{1}{2}$		S	$5\frac{1}{2}$	2	9
Reversed frames to frames	7					
Frames to tank side brackets—spacing not to exceed 7 diameters	See Table 11					
Tween deck frames to shell	7		S	7	3	$9\frac{1}{2}$
Intermediate frames to shell (D 1001 to D 1003)	7		S	7	3	$9\frac{1}{2}$
Bottom frames to shell and floors or floor plates to shell — Spacing not over 32 inches	7		S	7	3	$9\frac{1}{2}$ except in way of keel
„ over 32 inches and up to 34 inches	$6\frac{1}{2}$		S	$6\frac{1}{2}$	3	10 except in way of keel
„ „ 34 „	6		S	6	2	9 except in way of keel
in the forward ·25L	$5\frac{1}{2}$		S in peaks C Elsewhere	$5\frac{1}{2}$ $5\frac{1}{2}$	2 1	9 12
Floors and cross ties to frames in fore peak	6		S	6	2	9
„ „ „ „ aft „	5		S	5	2	$9\frac{1}{2}$
LONGITUDINAL FRAMING						
Bottom frames to shell and floors, or floor plates to shell (*see also* D 519)	5		S C for 2 spaces at ends	5	2	$9\frac{1}{2}$ continuous at ends
Bottom frames to shell and floors, or floor plates to shell when spacing of floors exceeds 8 feet	5		S C for 2 spaces at ends	5	2	$9\frac{1}{2}$ continuous at ends
Bottom longitudinals to shell in the forward ·25L	$5\frac{1}{2}$		S	$5\frac{1}{2}$	2	9
„ „ „ „ remainder	6		S	6	2	9
DOUBLE BOTTOMS (Transversely framed)						
Centre girder to keel	5 S.R.	2 if watertight	C	5		
„ „ „	$6\frac{1}{2}$ D.R.					
„ „ inner bottom (except in way of centre line bulkhead)	7	2 if watertight	C	6 in engine space and under thrust 7 elsewhere		
Centre girder to inner bottom (in way of centre line bulkhead)	5					
Floors to centre girder	5	Under engine, thrust and boiler bearers Elsewhere	C S	5 5	1 2	14 $9\frac{1}{2}$
Floors to intercostal side girders	7		S	7	3	$9\frac{1}{2}$
Intercostal side girder to shell	See Table 52 F		S	6	2	9
„ „ „ inner bottom under engine and thrust			C	6	1	12
„ „ „ „ „ elsewhere			S	7	3	$9\frac{1}{2}$
Reversed frames to floors and inner bottom or floor plates to inner bottom	6 D.R. 7 S.R.	Under engine and thrust Elsewhere	C S	6 7	1 3	12 $9\frac{1}{2}$
(For bottom frames to shell and floors or floor plates to shell *see* Transverse framing above)						
Margin plate to shell	$4\frac{1}{2}$	2				
Margin connection to tank side brackets and floors	See Table 11	Generally 1 in panting, 2 elsewhere (to depend on design)				
Boundaries of watertight and oiltight floors	5	1				
Stiffeners „ „ „	5		S	5	2	$9\frac{1}{2}$
Riveting and welding in way of heavy oil engines—To be specially considered.						

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED				
			INTERMITTENT FILLET WELDS			
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	DOUBLE CONTINUOUS FILLET WELDS	STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS	
		Type	S or C All Type 1	Distance (d) centre to centre	Type	Distance (d) centre to centre
				Inches		Inches
DOUBLE BOTTOMS (Longitudinally framed)						
Longitudinals to inner bottom	6		S	6	2	9
Bracket floors and longitudinal framing	See Table 8					
Floors to centre girder (*see also* D 519)	5		C	5		
" " " when spacing of floors exceeds 8 feet (*see also* D 519)	5	1				
Reversed frames to floors and inner bottom or floor plates to inner bottom (*see also* D 519)	5		S C for 2 spaces at ends of floors.	5	2	$9\frac{1}{2}$ One scallop per space for 2 spaces at ends of floors.
Reversed frames to floors and inner bottom or floor plates to inner bottom when spacing of floors exceeds 8 feet.	5 4 for 2 spaces at ends		S C for 2 spaces at ends	5 4 for 2 spaces at ends	2	$9\frac{1}{2}$ continuous for 2 spaces at ends
SINGLE BOTTOMS						
Centre keelson to keel	5		C	5		
Reversed frames or face plates to floors	7		S	7	3	$9\frac{1}{2}$
(For bottom frames to shell and floors or floor plates to shell *see* Transverse framing)						
Floors to centre keelson (double riveted connection where floors cut)	4	1				
Foundation plates to reversed frames	4					
Continuous keelson top angles or face plates to vertical keelson plates	7		S	7	3	One scallop per frame space
Butts of keelsons and foundation plates	4					
Connection of reversed frames to side keelsons—not less than 2 rivets.						
Side keelsons to shell	See Table 52 F		S	6	2	One scallop per frame space
Riveting or welding in way of machinery—to be specially considered.						
WATERTIGHT BULKHEADS, FLATS AND TUNNELS						
Horizontal connections of plating may be single riveted.						
Vertical connections of plating and boundary angles are to be double riveted when more than 35 feet below the top of the bulkhead.						
Overlaps of plating	$4\frac{1}{2}$					
Boundary connections to shell, inner bottom and decks	5	2				
" " " bulkhead	$4\frac{1}{2}$					
Stiffeners (except as below)	7		S	7	3	$9\frac{1}{2}$
Stiffeners, lugged or unattached, for 15 per cent of length at each end	4		S	4	2	12
Brackets and lugs	See Table 36		See Table 36			
BULKHEADS OF DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS						
Overlaps of plating and boundary angles to be single or double riveted as for watertight bulkheads.						
Overlaps of plating	4					
Stiffeners, bracketed	6		S	6	2	9
Boundary connections	As for W.T. bulkheads	1 at bottom and bilge 2 at deck and side				
Brackets	See Table 36		See Table 36			

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED				
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS			
			STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS	
		Type	S or C All Type 1	Distance (d) centre to centre	Type	Distance (d) centre to centre
				Inches		Inches
OIL FUEL BUNKERS						
Where not otherwise required to be increased, the overlaps of plating of bulkheads, shell and deck and the stringer angle may be single riveted if not more than 28 feet below the top of the overflow or 16 feet below the top of the tank; elsewhere the riveting is to be double.						
Centre line bulkheads may be single riveted throughout						
Overlaps of bulkhead, inner bottom and deck plating ...	4					
Deck stringer connection	4	2—except at strength deck				
Boundary connections	5 D.R.	1 at bottom and bilge 2 at deck and side				
Stiffeners bracketed	6		S	6	2	9
Horizontal girders to shell and bulkheads (*see also* D 2006 to D 2010) ...	$4\frac{1}{2}$		S; C at brackets	$4\frac{1}{2}$	2—clear of brackets 1—at brackets	$9\frac{1}{2}$ 17
Horizontal girders—brackets	$4\frac{1}{2}$ D.R.		C	$4\frac{1}{2}$ if overlapped		
„ „ —face angles or plates	7		S	6	2	9
Stiffener brackets	See Table 36		See Table 36			
NON-WATERTIGHT BULKHEADS						
Overlaps of plating	6					
Boundary connections to inner bottom, horizontal riveted flange (*see also* D 1802)	5		S	5		
Boundary connections elsewhere	7		S	7		
Stiffeners	7		S	8	3	9
DECKS						
Stringer angle on strength decks	See Table 19					
„ „ lower „	„ „ 52 F					
BEAMS AND DECK LONGITUDINALS						
Beams to deck	7		S	7	3	$9\frac{1}{2}$
„ at crown of deep tanks, peak tanks and oil fuel tanks	6		S	6	2	9
Strong beams at ends of hatchways, deck connections (*see also* Deck girders)	5		S	5	2	$9\frac{1}{2}$
Half beams to hatch coamings and casings—lugs of same thickness as coaming with 2 rivets or 1 sq. inch of welding in each flange for beams not exceeding 8 inches, and 3 rivets or 1·5 sq. inch of welding for beams exceeding 8 inches in depth.						
Longitudinals to deck	6		S	6	2	9
Beam knees	See Table 28		See Table 28			
DECK GIRDERS, TRANSVERSES AND WEBS						
Connections to plating (*see also* D 1505 to D 1508)	5		S	5	2	$9\frac{1}{2}$
Face section, not exceeding 6 sq. inches area, to web ...	7		S	7	3	$9\frac{1}{2}$
„ „ exceeding 6 sq. inches area, to web	6		S	6	2	9
End brackets	5 D.R.	2	C	$4\frac{1}{2}$		
Butts of girders	4					

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED				
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS			
			STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS	
		Type	S or C All Type 1	Distance (d) centre to centre	Type	Distance (d) centre to centre
				Inches		Inches
PILLARS						
Heads and heels of solid pillars	See Table 31					
Seams of tubular pillars	5					
Riveting or welding of pillars built of rolled sections	7		S	7		
End connections of widely spaced built pillars	5	2				
HATCHWAYS						
Coaming to deck	5	2				
„ „ at corners	$4\frac{1}{2}$	1				
Stiffener to coaming	7		S	7	3	$9\frac{1}{2}$
Horizontal stiffeners on coaming where forming watertight recess	5	2				
Hatch beam angles or face plates	7		S	7	3	$9\frac{1}{2}$
Vertical corner angles	5					
VENTILATORS						
Connection to deck (*see also* D 2403)	4	2				
DECKHOUSES						
Overlaps of outer casings	5					
„ inner „	6					
Foundation connections (*see also* D 1209 to D 1210)	5	2				
Stiffeners	7		S	7	3	$9\frac{1}{2}$
MASTS						
End laps are to be treble riveted and seams single riveted.						
Overlaps of plating	5					
RUDDERS						
Spacing of rivets in arms (*see also* D 2618)	$4\frac{1}{2}$					
STEMS AND STERNFRAMES						
Connections to shell plating: diameter of rivet with solid sections to be $\frac{1}{4}$ inch greater than required for the thickness of the plating and $\frac{1}{8}$ inch greater for castings or built frames but not to exceed $1\frac{1}{8}$ inch	5					
In ships above 350 feet in length shell plating is to be connected to sternframe below the boss by three rows of rivets.						
Connection to transom plate: for ships not exceeding 300 feet in length by two single riveted angles, in ships above 300 feet in length by two double riveted angles	5					

TABLE 53

EQUIPMENT

Equipment Number (*See* D 3503 and D 4011)	Equipt. Letter	Stockless Bower Anchors		Stocked Stream Anchor	Stud Link Chain Cable			Stream Wire or Chain			Towline			Mooring Ropes			
						Minimum Diameter						Circumference				Circumference	
		Number	Weight Per Anchor	Weight Ex Stock	Number of 15 fathom Lengths	Wrought Iron or Mild Steel	Special Steel (*see notes*)	Length	Wire Circumference	Short Link Chain dia.	Length	Wire	Fibre (3 strand)	Number	Length of Each	Wire	Fibre (4 strand)
			Cwt.	Cwt.		Inches	Inches	Fms.	Inches	Inches	Fms.	Inches	Inches		Fms.	Inches	Inches
3000	*a*	2	4 3/8	3/4	8	1 1/16		45	2	9/16	70	2	5	2	70		3
3600	*b*	2	5 1/4	1 1/4	8	3/4		45	2 1/4	5/8	70	2	5	2	70		3
4200	*c*	2	6 1/4	1 3/4	9	1 3/16		50	2 1/4	5/8	80	2 1/4	5	2	80		3
4800	*d*	2	7 1/8	2 1/4	10	7/8		50	(*a*) 2 1/2	1 1/16	80	2 1/4	5 1/2	2	80		3
5400	*e*	2	8 1/8	2 3/4	10	1 5/16		50	2 1/2	1 1/16	80	2 1/4	5 1/2	2	90	1 1/2	3 1/2
6000	*f*	2	9	3 1/4	11	1		50	2 3/4	3/4	80	2 1/2	5 1/2	2	90	1 1/2	3 1/2
6700	*g*	3	9 3/4		12	1 1/16					80	2 1/2	6	2	90	1 1/2	3 1/2
7400	*h*	3	11 5/8		13	1 1/8					80	2 3/4	6	2	90	1 3/4	4
8100	*i*	3	13 7/8		13	1 3/16					90	2 3/4	6 1/2	2	90	1 3/4	4
8900	*j*	3	16		14	1 1/4					90	3	6 1/2	2	90	1 3/4	4
9700	*k*	3	18		14	1 5/16					90	3	7	3	90	1 3/4	4
10600	*l*	3	20 1/8		14	1 3/8					90	3	7	3	90	1 3/4	4
11600	*m*	3	22 1/4		14	1 7/16	1 1/4				90	(*a*) 3 1/4	8	3	90	2	4
12700	*n*	3	24 1/2		14	1 1/2	1 5/16				90	3 1/4	8	3	90	2	4 1/2
13900	*o*	3	26 3/4		16	1 9/16	1 3/8				100	3 1/2	9	3	90	2 1/4	5
15200	*p*	3	29		16	1 5/8	1 7/16				100	3 1/2	9	3	90	2 1/4	5 1/2
16800	*q*	3	31 3/8		16	1 11/16	1 7/16				100	4	9	3	100	2 1/2	5 1/2
18600	*r*	3	33 7/8		16	1 3/4	1 1/2				100	4	10	3	100	2 1/2	6
20600	*s*	3	36 7/8		16	1 13/16	1 9/16				100	4		3	100	2 3/4	6
22700	*t*	3	39 7/8		16	1 7/8	1 5/8				100	4 1/2		3	100	2 3/4	6 1/2
25000	*u*	3	43 1/4		18	1 15/16	1 11/16				110	4 1/2		3	100	(*a*) 2 3/4	6 1/2
27300	*v*	3	46 5/8		18	2	1 3/4				110	4 1/2		4	100	2 3/4	6 1/2
29700	*w*	3	50		18	2 1/16	1 13/16				110	5		4	100	2 3/4	6 1/2
32200	*x*	3	53 3/4		18	2 1/8	1 13/16				110	5		4	100	2 3/4	7
34800	*y*	3	57 1/2		18	2 3/16	1 7/8				110	4 1/2		4	100	3	7
37600	*z*	3	61 1/2		18	2 1/4	1 15/16				110	4 1/2		4	100	3	7
40400	*a*†	3	65 1/2		18	2 5/16	2				120	5		4	100	3	7
43200	*b*†	3	69 1/2		20	2 3/8	2 1/16				120	5		4	100	3 1/4	7
46000	*c*†	3	73 1/2		20	2 7/16	2 1/8				120	5		4	110	3 1/4	8
48800	*d*†	3	77 3/4		20	2 1/2	2 3/16				120	5 1/2		4	110	3 1/4	8
51600	*e*†	3	81 3/4		20	2 9/16	2 1/4				120	5 1/2		4	110	3 1/4	8
54600	*f*†	3	86		20	2 5/8	2 1/4				120	5 1/2		5	110	3 1/4	8
57600	*g*†	3	90 1/4		22	2 11/16	2 5/16				130	(*b*) 6		5	110	3 1/4	8
60600	*h*†	3	94 1/2		22	2 3/4	2 3/8				130	6		5	110	3	8
63800	*i*†	3	99		22	2 13/16	2 7/16				130	6 1/2		5	110	3	8
67000	*j*†	3	103 1/2		22	2 7/8	2 1/2				130	6 1/2		5	110	3	9
70200	*k*†	3	107 3/4		22	2 15/16	2 9/16				130	6 1/2		5	110	3	9
73400	*l*†	3	112		22	3	2 5/8				130	7		5	110	3	9
76800	*m*†	3	116 1/4		22	3 1/16	2 11/16				140	7		5	110	3 1/4	9
80200	*n*†	3	120 1/2		22	3 1/8	2 3/4				140	7		5	110	3 1/4	9
83800	*o*†	3	125		22	3 3/16	2 13/16				140	7		5	120	3 1/4	9
87600	*p*†	3	129 3/4		22	3 1/4	2 13/16				140	7		5	120	3 1/4	9
91600	*q*†	3	134 3/4		22	3 5/16	2 7/8				140	7		6	120	3 1/4	9
95800	*r*†	3	140		22	3 3/8	2 15/16				140	7		6	120	3 1/4	9
100200	*s*†	3	145 1/2		22	3 7/16	3				150	7 1/2		6	120	(*b*) 3 1/4	9
105000	*t*†	3	151 1/2		22	3 1/2	3 1/16				150	7 1/2		6	120	3 1/4	9
110000	*u*†	3	157 1/2		22	3 9/16	3 1/8				150	(*c*) 7 1/2		6	120	3 1/4	9
115000	*v*†	3	163 1/2		22	3 5/8	3 3/16				150	7 1/2		6	120	3 1/2	10
120000	*w*†	3	169 1/2		22	3 11/16	3 1/4				150	8		6	120	3 1/2	10
125000	*x*†	3	175 1/2		22	3 3/4	3 5/16				150	8		6	120	3 1/2	10
130000	*y*†	3	181 1/2		22	3 13/16	3 3/8				150	8		6	120	3 1/2	10
135000	*z*†	3	188		22	3 7/8	3 7/16				150	8		6	120	3 1/2	10

(*a*) = 6 × 12 Flexible Steel Wire Rope. (*b*) = 6 × 24 Flexible Steel Wire Rope. (*c*) = 6 × 37 Special Flexible Steel Wire Rope.

TABLE 53

NOTES. — TABLE 53

1. Where the Equipment Number lies between any two consecutive numbers given in the Table, the equipment is to be governed by the greater.

2. Bower Anchors. The weight per anchor given in the Table is for anchors of equal weight. The weight of individual anchors may vary $\pm$ 7 per cent from the Table weight provided the total weight of anchors is not less than would have been required for anchors of equal weight.

3. If it is desired to use stocked bower anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

4. Special Steel Cable is cable which has been subjected to proof and breaking tests 40 per cent in excess of those required for wrought iron cable (P 1701).

5. The weight of each 15 fathom length of cable, including one joining shackle, is not to be less than that given in P 1701.

6. Steel wire ropes other than those given in the Table may be used if of equivalent strength.

7. Ropes of strength equivalent to the fibre 3-strand and fibre 4-strand given for towline and mooring ropes may be used.

8. Tests. *See* P 1504 for anchors.
P 1701 for cables.
P 1806 to P 1808 for wire ropes.
P 1809 for fibre ropes.

TABLE 54 EQUIPMENT FOR TUGS

EQUIPMENT NUMBER	STOCKLESS BOWER ANCHORS		WROUGHT IRON OR MILD STEEL STUD LINK CHAIN CABLE		FIBRE MOORING ROPES (4-strand)		
	Number	Minimum weight of each anchor	Number of 15 fathom lengths	Diameter	Length of each	Circumference	
						First	Second
		Cwt.		Inches	Fathoms	Inches	Inches
1440	2	$3\frac{1}{4}$	4	$\frac{5}{8}$	60	$4\frac{1}{4}$	$2\frac{1}{2}$
1700	2	$3\frac{1}{2}$	4	$\frac{11}{16}$	60	$4\frac{1}{2}$	$2\frac{1}{2}$
1970	2	$3\frac{3}{4}$	4	$\frac{11}{16}$	60	$4\frac{3}{4}$	$2\frac{1}{2}$
2240	2	4	4	$\frac{3}{4}$	60	$4\frac{3}{4}$	$2\frac{1}{2}$
2510	2	$4\frac{1}{4}$	4	$\frac{13}{16}$	60	5	$2\frac{3}{4}$
2780	2	$4\frac{1}{2}$	5	$\frac{13}{16}$	60	5	3
3050	2	$4\frac{3}{4}$	5	$\frac{7}{8}$	60	$5\frac{1}{2}$	$3\frac{1}{4}$
3330	2	5	5	$\frac{7}{8}$	60	$5\frac{1}{2}$	$3\frac{1}{2}$
3620	2	$5\frac{3}{8}$	5	$\frac{15}{16}$	60	$5\frac{1}{2}$	$3\frac{3}{4}$
3910	2	$5\frac{3}{4}$	6	$\frac{15}{16}$	60	$5\frac{1}{2}$	4
4200	2	$6\frac{1}{8}$	6	1	60	6	$4\frac{1}{4}$
4490	2	$6\frac{3}{8}$	6	1	60	6	$4\frac{1}{2}$
4780	2	$6\frac{3}{4}$	7	$1\frac{1}{16}$	60	6	$4\frac{3}{4}$
5080	2	7	7	$1\frac{1}{16}$	60	6	5
5380	2	$7\frac{3}{8}$	7	$1\frac{1}{8}$	60	$6\frac{1}{2}$	5
5690	2	$7\frac{5}{8}$	8	$1\frac{1}{8}$	60	$6\frac{1}{2}$	5
6000	2	8	8	$1\frac{1}{8}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6310	2	$8\frac{3}{8}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6620	2	$8\frac{3}{4}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6940	2	$9\frac{1}{4}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
7260	2	$9\frac{3}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
7590	2	$10\frac{1}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
7920	2	$10\frac{3}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
8260	2	$11\frac{3}{8}$	11	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
8600	3	12	11	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
8950	3	$12\frac{3}{4}$	12	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
9300	3	$13\frac{1}{2}$	12	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
9650	3	$14\frac{5}{8}$	12	$1\frac{3}{8}$	60	7	$5\frac{1}{2}$
10000	3	$15\frac{3}{4}$	13	$1\frac{3}{8}$	60	7	$5\frac{1}{2}$
10350	3	$16\frac{7}{8}$	13	$1\frac{3}{8}$	90	7	$5\frac{1}{2}$
10700	3	$18\frac{1}{8}$	14	$1\frac{3}{8}$	90	7	$5\frac{1}{2}$
11050	3	$19\frac{1}{2}$	14	$1\frac{7}{16}$	90	7	$5\frac{1}{2}$

NOTES.—TABLE 54

1. Where the Equipment Number lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

2. If it is desired to use stocked anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

3. If it is desired to use short link chain the diameter is to be that for which the same proof test is required as for the stud link chain given in the Table. *See* P 1701.

4. Tests. *See* P 1504 for anchors.
P 1701 for cables.
P 1806 to P1808 for wire ropes.
P 1809 for fibre ropes.

RENEWAL OF STEERING CHAINS & CHAIN CABLES WHEN WORN

When any length of a chain is so worn that the mean diameter at its most worn part is reduced to the size given in the following Table it is to be renewed.

ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
3/8	11/32	1 5/16	1 3/16	2 1/4	2	3 3/16	2 7/8
7/16	13/32	1 3/8	1 7/32	2 5/16	2 1/16	3 1/4	2 15/16
1/2	7/16	1 7/16	1 9/32	2 3/8	2 1/8	3 5/16	2 31/32
9/16	1/2	1 1/2	1 11/32	2 7/16	2 3/16	3 3/8	3 1/32
5/8	9/16	1 9/16	1 13/32	2 1/2	2 1/4	3 7/16	3 1/16
11/16	5/8	1 5/8	1 15/32	2 9/16	2 9/32	3 1/2	3 1/8
3/4	21/32	1 11/16	1 1/2	2 5/8	2 11/32	3 9/16	3 3/16
13/16	23/32	1 3/4	1 9/16	2 11/16	2 13/32	3 5/8	3 1/4
7/8	25/32	1 13/16	1 5/8	2 3/4	2 15/32	3 11/16	3 5/16
15/16	27/32	1 7/8	1 11/16	2 13/16	2 17/32	3 3/4	3 3/8
1	29/32	1 15/16	1 23/32	2 7/8	2 9/16	3 13/16	3 7/16
1 1/16	15/16	2	1 25/32	2 15/16	2 5/8	3 7/8	3 1/2
1 1/8	1	2 1/16	1 27/32	3	2 11/16		
1 3/16	1 1/16	2 1/8	1 29/32	3 1/16	2 3/4		
1 1/4	1 1/8	2 3/16	1 31/32	3 1/8	2 13/16		

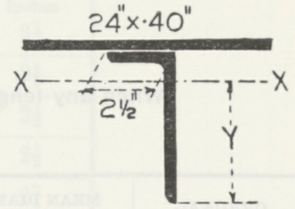
TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

ANGLES HAVING $2\frac{1}{2}$-in. FLANGE



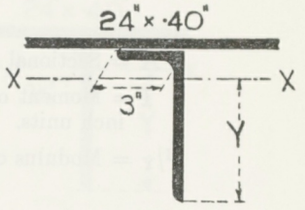
DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·20	·22	·24	·26	·28	·30	·32	·34	·36	·38	·40
$2\frac{1}{2}$	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67	1·76	1·84
	I	1·20	1·32	1·44	1·56	1·68	1·80	1·92	2·05	2·18	2·30	2·43
	$I/_Y$	·46	·50	·55	·60	·65	·70	·75	·80	·85	·90	·96
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85	1·95	2·04
	I	2·03	2·26	2·49	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00
	$I/_Y$	·66	·72	·78	·85	·92	·99	1·06	1·13	1·20	1·27	1·33
$3\frac{1}{2}$	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24
	I		3·40	3·70	3·95	4·20	4·50	4·80	5·10	5·38	5·66	5·94
	$I/_Y$		·96	1·04	1·13	1·21	1·30	1·38	1·47	1·55	1·63	1·72

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·42	·44	·46	·48	·50	·52	·54	·56	·58	·60	·62
$2\frac{1}{2}$	A	1·92	2·01	2·09	2·17	2·25	2·33	2·41				
	I	2·56	2·68	2·80	2·92	3·04	3·15	3·26				
	$I/_Y$	1·01	1·06	1·11	1·16	1·21	1·26	1·30				
3	A	2·13	2·23	2·32	2·41	2·50	2·59	2·68	2·77	2·85		
	I	4·20	4·40	4·59	4·75	4·90	5·05	5·21	5·36	5·51		
	$I/_Y$	1·39	1·45	1·51	1·59	1·63	1·69	1·76	1·83	1·90		
$3\frac{1}{2}$	A	2·34	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	3·24	
	I	6·22	6·50	6·78	7·05	7·32	7·56	7·80	8·10	8·40	8·60	
	$I/_Y$	1·81	1·90	1·99	2·07	2·16	2·24	2·32	2·41	2·50	2·58	

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

ANGLES HAVING 3-in. FLANGE



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34	2·45	2·55
	I	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00	4·20	4·40	4·60
	$I/_Y$	·85	·92	·99	1·06	1·13	1·20	1·27	1·33	1·39	1·45	1·51
3½	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55	2·67	2·78
	I	4·00	4·20	4·50	4·80	5·10	5·40	5·70	6·00	6·30	6·60	6·90
	$I/_Y$	1·14	1·22	1·30	1·38	1·47	1·56	1·65	1·73	1·82	1·92	2·02
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01
	I	5·80	6·20	6·60	7·00	7·40	7·80	8·20	8·60	9·00	9·40	9·80
	$I/_Y$	1·45	1·56	1·67	1·78	1·89	2·00	2·10	2·20	2·30	2·40	2·52
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47
	I	9·75	11·00	12·25	13·00	13·75	14·50	15·20	15·90	16·60	17·30	18·00
	$I/_Y$	2·00	2·27	2·55	2·70	2·86	3·01	3·16	3·32	3·48	3·64	3·80
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93
	I	18·70	19·90	21·00	22·10	23·20	24·30	25·40	26·50	27·60	28·70	29·80
	$I/_Y$	3·26	3·47	3·68	3·89	4·09	4·31	4·53	4·75	4·98	5·20	5·42

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·48	·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70
3	A	2·65	2·75	2·85	2·95	3·05	3·14						
	I	4·80	4·90	5·10	5·25	5·40	5·60						
	$I/_Y$	1·59	1·63	1·69	1·76	1·83	1·90						
3½	A	2·89	3·00	3·11	3·22	3·33	3·43	3·54					
	I	7·20	7·40	7·60	7·80	8·20	8·40	8·60					
	$I/_Y$	2·10	2·17	2·24	2·32	2·41	2·50	2·58					
4	A	3·13	3·25	3·37	3·49	3·61	3·72	3·84	3·96				
	I	10·20	10·50	10·90	11·30	11·70	12·00	12·30	12·60				
	$I/_Y$	2·63	2·74	2·85	2·96	3·07	3·17	3·28	3·39				
5	A	3·61	3·75	3·89	4·03	4·17	4·30	4·44	4·58	4·71	4·84		
	I	18·70	19·30	20·00	20·70	21·30	22·00	22·70	23·30	24·00	24·60		
	$I/_Y$	3·96	4·12	4·28	4·45	4·61	4·77	4·93	5·09	5·25	5·41		
6	A	4·09	4·25	4·41	4·57	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81
	I	30·90	32·00	33·10	34·20	35·30	36·40	37·40	38·40	39·40	40·40	41·40	42·40
	$I/_Y$	5·63	5·86	6·08	6·30	6·51	6·72	6·94	7·16	7·38	7·60	7·81	8·03

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

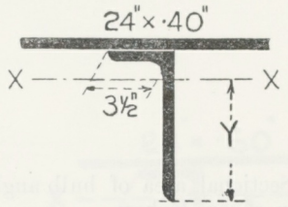
ANGLES HAVING

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units.
$I/_Y$ = Modulus of resistance of section in inch units.
} In conjunction with plating.

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
$3\frac{1}{2}$	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	3·7	4·0	4·3	4·6	4·9	5·1	5·3	5·6	5·9	6·2	6·5	6·8
	$I/_Y$	1·04	1·13	1·22	1·31	1·40	1·48	1·56	1·65	1·73	1·82	1·91	2·00
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	6·0	6·3	6·7	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
	$I/_Y$	1·46	1·56	1·66	1·76	1·87	1·98	2·09	2·20	2·30	2·41	2·52	2·63
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	10·6	11·4	12·2	13·0	13·7	14·4	15·1	15·8	16·5	17·2	18·0	18·7
	$I/_Y$	2·25	2·40	2·55	2·70	2·87	3·03	3·19	3·35	3·51	3·68	3·84	4·00
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			20·4	21·6	22·8	24·0	25·2	26·4	27·6	28·8	29·9	31·0
	$I/_Y$			3·58	3·82	4·04	4·27	4·50	4·72	4·95	5·18	5·40	5·62
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					35·5	37·2	38·9	40·6	42·3	44·0	45·7	47·4
	$I/_Y$					5·44	5·74	6·04	6·34	6·64	6·94	7·24	7·53

GEOMETRICAL PROPERTIES OF SECTIONS

3½-in. FLANGE



THICKNESS OF WEB IN INCHES													ITEM	DEPTH OF WEB IN INCHES
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74		
3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07						A	3½
7·1	7·3	7·6	7·9	8·1	8·4	8·7	9·0						I	
2·09	2·18	2·26	2·34	2·42	2·50	2·59	2·70						I/Y	
3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51					A	4
10·6	10·9	11·2	11·6	12·0	12·3	12·6	13·0	13·4					I	
2·74	2·85	2·95	3·06	3·17	3·28	3·39	3·50	3·61					I/Y	
4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46			A	5
19·4	20·0	20·6	21·3	22·0	22·6	23·2	23·8	24·4	25·0	25·6			I	
4·15	4·32	4·48	4·64	4·80	4·95	5·12	5·28	5·44	5·60	5·68			I/Y	
4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48	A	6
32·1	33·2	34·2	35·3	36·3	37·4	38·4	39·4	40·4	41·4	42·3	43·2	44·1	I	
5·84	6·06	6·28	6·50	6·72	6·94	7·16	7·38	7·60	7·82	8·04	8·25	8·46	I/Y	
5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22	A	7
49·1	50·7	52·3	53·9	55·5	57·0	58·5	60·0	61·5	63·0	64·5	65·9	67·2	I	
7·82	8·11	8·40	8·69	8·98	9·26	9·55	9·84	10·13	10·41	10·70	10·98	11·25	I/Y	

TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

BULB ANGLE

A = Sectional area of bulb angles in square inches.

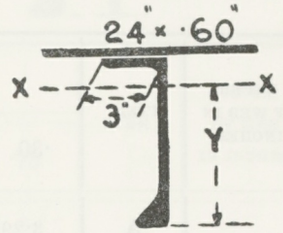
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.

$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
5	A	2·52	2·66	2·79	2·92	3·06	3·19	3·32	3·45	3·59	3·72	3·85
	I	19·8	20·7	21·5	22·4	23·4	24·4	25·3	26·3	27·3	28·3	29·3
	$I/_Y$	4·00	4·20	4·40	4·55	4·75	4·95	5·15	5·35	5·55	5·75	6·00
$5\frac{1}{2}$	A		2·88	3·02	3·16	3·31	3·45	3·59	3·72	3·86	4·00	4·15
	I		27·7	28·8	29·9	31·0	32·2	33·4	34·5	35·7	36·9	38·1
	$I/_Y$		5·15	5·40	5·60	5·80	6·05	6·25	6·50	6·70	6·95	7·20
6	A		3·12	3·27	3·42	3·58	3·73	3·88	4·03	4·18	4·33	4·48
	I		36·1	37·5	39·0	40·5	42·1	43·7	45·3	46·8	48·3	49·8
	$I/_Y$		6·25	6·50	6·80	7·10	7·35	7·65	7·90	8·20	8·45	8·75
7	A				3·96	4·13	4·30	4·47	4·64	4·81	4·99	5·16
	I				62·7	64·7	66·7	68·8	70·9	73·0	75·2	77·5
	$I/_Y$				9·60	9·95	10·25	10·60	10·95	11·30	11·65	12·05
8	A					4·68	4·88	5·07	5·26	5·45	5·64	5·83
	I					97·7	100·5	103·4	106·5	109·6	112·6	115·8
	$I/_Y$					13·45	13·85	14·30	14·75	15·20	15·65	16·10

GEOMETRICAL PROPERTIES OF SECTIONS

HAVING 3-in. FLANGE



THICKNESS OF WEB IN INCHES											ITEM	DEPTH OF WEB IN INCHES
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70		
3·99 30·2 6·20	4·12 31·2 6·40	4·25 32·2 6·60	4·38 33·1 6·80								A I I/Y	5
4·29 39·4 7·45	4·43 40·6 7·70	4·57 41·9 7·95	4·71 43·4 8·20								A I I/Y	5½
4·63 51·2 9·00	4·78 52·8 9·30	4·94 54·3 9·60	5·09 55·8 9·85	5·24 57·2 10·10							A I I/Y	6
5·33 79·8 12·40	5·50 82·0 12·80	5·67 84·2 13·15	5·84 86·4 13·50	6·02 88·5 13·85	6·19 90·6 14·20						A I I/Y	7
6·02 119·0 16·60	6·21 122·0 17·10	6·40 125·0 17·55	6·60 128·0 18·00	6·79 130·9 18·45	6·98 133·7 18·90	7·17 136·5 19·30					A I I/Y	8

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

BULB ANGLE

A = Sectional area of bulb angles in square inches.
I = Moment of inertia about neutral axis X X in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
6	A	3·29	3·45	3·60	3·76	3·98	4·07	4·23	4·39	4·55	4·70	4·86	5·02	5·18
	I	36·5	37·9	39·3	40·8	42·3	43·8	45·4	46·9	48·4	49·9	51·4	52·9	54·4
	$I/_Y$	6·35	6·60	6·85	7·10	7·40	7·65	7·95	8·20	8·50	8·80	9·05	9·35	9·65
7	A			4·15	4·32	4·50	4·68	4·86	5·03	5·21	5·39	5·56	5·74	5·92
	I			62·8	64·9	66·9	69·0	71·1	73·2	75·4	77·7	80·0	82·3	84·6
	$I/_Y$			9·65	9·95	10·25	10·60	10·95	11·30	11·65	12·05	12·45	12·80	13·20
8	A				4·89	5·08	5·28	5·47	5·67	5·86	6·05	6·25	6·44	6·64
	I				98·0	100·9	103·9	107·0	110·1	113·2	116·4	119·5	122·5	125·4
	$I/_Y$				13·45	13·85	14·35	14·80	15·25	15·75	16·20	16·70	17·15	17·60
9	A					5·70	5·92	6·13	6·35	6·57	6·78	7·00	7·22	7·43
	I					148·0	151·5	155·0	159·0	163·0	167·0	171·0	175·0	179·0
	$I/_Y$					18·40	18·90	19·40	19·90	20·50	21·05	21·60	22·20	22·70
10	A						6·57	6·80	7·04	7·28	7·51	7·75	7·98	8·22
	I						211·0	215·5	220·5	225·5	230·5	235·5	240·5	246·0
	$I/_Y$						24·20	24·80	25·45	26·10	26·80	27·40	28·10	28·80
11	A							7·50	7·76	8·02	8·28	8·53	8·79	9·05
	I							286·4	292·0	298·1	304·2	310·3	316·6	323·2
	$I/_Y$							30·80	31·55	32·30	33·05	33·80	34·55	35·40
12	A								8·50	8·77	9·05	9·33	9·61	9·89
	I								382·0	389·0	396·1	403·8	411·5	419·5
	$I/_Y$								38·65	39·45	40·30	41·20	42·10	43·05

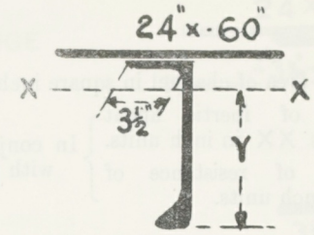
BULB ANGLE

$13\frac{1}{2}$	A									10·22	10·54	10·84	11·15	11·47
	I									564·6	572·0	580·0	588·8	598·4
	$I/_Y$									52·40	53·30	54·20	55·25	56·30

GEOMETRICAL PROPERTIES OF SECTIONS

TABLE 56
(SEE CONTINUATION)

HAVING $3\frac{1}{2}$-in. FLANGE



THICKNESS OF WEB IN INCHES												ITEM	DEPTH OF WEB IN INCHES
·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78		
5·34	5·49	5·65	5·81									A	6
55·9	57·3	58·7	60·0									I	
9·90	10·15	10·40	10·65									$I/_Y$	
6·09	6·27	6·45	6·62	6·80								A	7
86·8	88·9	91·0	93·2	95·3								I	
13·55	13·95	14·30	14·65	15·00								$I/_Y$	
6·83	7·03	7·23	7·42	7·62	7·81							A	8
128·3	131·1	133·9	136·8	139·6	142·4							I	
18·05	18·50	18·90	19·35	19·75	20·20							$I/_Y$	
7·65	7·87	8·08	8·30	8·52	8·73	8·95						A	9
183·0	187·0	191·0	195·0	199·0	203·0	207·0						I	
23·30	23·85	24·45	25·00	25·6	26·15	26·70						$I/_Y$	
8·46	8·69	8·92	9·16	9·40	9·64	9·88	10·12	10·35				A	10
251·0	256·0	261·0	266·0	271·0	276·0	281·0	286·0	291·0				I	
29·45	30·10	30·80	31·45	32·10	32·80	33·50	34·20	34·80				$I/_Y$	
9·31	9·56	9·82	10·07	10·33	10·59	10·84	11·09	11·35	11·60			A	11
329·7	336·2	342·6	349·0	355·3	361·4	367·5	373·4	379·3	385·0			I	
36·20	37·00	37·80	38·60	39·40	40·20	40·95	41·70	42·45	43·20			$I/_Y$	
10·17	10·44	10·72	10·99	11·27	11·55	11·83	12·10	12·38	12·65	12·93		A	12
427·5	435·5	443·5	451·2	458·9	466·4	473·7	481·0	488·2	495·1	501·9		I	
44·00	44·95	45·90	46·85	47·75	48·65	49·55	50·45	51·30	52·15	53·00		$I/_Y$	

HAVING 4-in. FLANGE

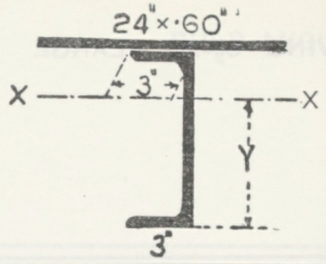
11·78	12·09	12·41	12·72	13·03	13·34	13·65	13·96	14·28	14·59	14·90	15·21	A	$13\frac{1}{2}$
608·5	618·5	628·5	639·0	650·0	660·5	671·0	681·0	691·0	701·0	710·5	720·0	I	
57·40	58·50	59·60	60·80	61·95	63·15	64·30	64·65	66·50	67·60	68·70	69·80	$I/_Y$	

TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

CHANNELS HAVING 3-in. FLANGE



A = Sectional area of channel in square inches.
I = Moment of inertia about neutral axis XX in inch units.
$I/_Y$ = Modulus of resistance of section in inch units.
} In conjunction with plating.

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
			·24	·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
6	·38	A	3·59	3·71	3·83	3·95	4·07	4·19	4·31	4·43	4·55	4·67	4·79	4·91	5·03
		I	52·4	53·6	54·8	55·9	57·1	58·3	59·4	60·5	61·6	62·7	63·8	64·9	66·0
		$I/_Y$	9·25	9·50	9·75	10·0	10·25	10·5	10·75	10·95	11·2	11·4	11·65	11·9	12·1
7	·42	A		4·18	4·32	4·46	4·60	4·74	4·88	5·02	5·16	5·30	5·44	5·58	5·72
		I		79·5	81·3	83·1	84·8	86·5	88·2	89·9	91·6	93·3	95·0	96·6	98·2
		$I/_Y$		12·35	12·65	13·0	13·3	13·6	13·9	14·25	14·55	14·85	15·2	15·5	15·8
8	·44	A			4·69	4·85	5·01	5·17	5·33	5·49	5·65	5·81	5·97	6·13	6·29
		I			112·2	114·7	117·2	119·7	122·1	124·5	126·9	129·3	131·6	133·9	136·2
		$I/_Y$			15·5	15·9	16·3	16·7	17·1	17·5	17·9	18·3	18·7	19·1	19·5
9	·44	A				5·14	5·32	5·50	5·68	5·86	6·04	6·22	6·40	6·58	6·76
		I				149·7	153·1	156·5	159·9	163·3	166·7	170·0	173·2	176·4	179·5
		$I/_Y$				18·6	19·15	19·65	20·15	20·65	21·15	21·65	22·15	22·65	23·15
10	·45	A					5·67	5·87	6·07	6·27	6·47	6·67	6·87	7·07	7·27
		I					197·0	201·5	206·0	210·4	214·8	219·1	223·3	227·5	231·7
		$I/_Y$					22·4	23·0	23·6	24·2	24·8	25·4	26·0	26·6	27·2

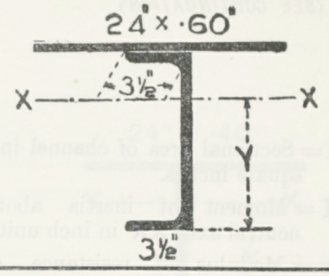
DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
			·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
6	·38	A	5·15	5·27	5·39	5·51	5·63	5·75	5·87	5·99	6·11				
		I	67·1	68·2	69·3	70·4	71·4	72·4	73·4	74·4	75·4				
		$I/_Y$	12·35	12·6	12·85	13·05	13·3	13·5	13·75	13·95	14·15				
7	·42	A	5·86	6·00	6·14	6·28	6·42	6·56	6·70	6·84	6·98	7·12			
		I	99·8	101·4	103·0	104·6	106·1	107·6	109·1	110·6	112·1	113·6			
		$I/_Y$	16·1	16·4	16·7	17·05	17·35	17·6	17·9	18·2	18·55	18·85			
8	·44	A	6·45	6·61	6·77	6·93	7·09	7·25	7·41	7·57	7·73	7·89	8·05		
		I	138·5	140·8	143·0	145·2	147·4	149·6	151·8	154·0	156·1	158·2	160·3		
		$I/_Y$	19·9	20·3	20·65	21·05	21·4	21·8	22·2	22·6	22·95	23·35	23·7		
9	·44	A	6·94	7·12	7·30	7·48	7·66	7·84	8·02	8·20	8·38	8·56	8·74	8·92	
		I	182·6	185·7	188·7	191·7	194·7	197·7	200·6	203·5	206·4	209·3	212·1	214·9	
		$I/_Y$	23·6	24·1	24·55	25·0	25·5	26·0	26·45	26·9	27·35	27·85	28·3	28·75	
10	·45	A	7·47	7·67	7·87	8·07	8·27	8·47	8·67	8·87	9·07	9·27	9·47	9·67	9·87
		I	235·9	240·0	244·0	248·0	251·9	255·8	259·7	263·5	267·3	271·1	274·9	278·7	282·4
		$I/_Y$	27·8	28·35	28·95	29·5	30·1	30·65	31·25	31·8	32·4	33·0	33·5	34·05	34·6

GEOMETRICAL PROPERTIES OF SECTIONS

TABLE 56

(SEE CONTINUATION)

CHANNELS HAVING 3½-in. FLANGE



A = Sectional area of channel in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
			·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50
6	·48	A	4·73	4·85	4·97	5·09	5·21	5·33	5·45	5·57	5·69	5·81	5·93	6·05	6·17
		I	67·4	68·4	69·4	70·5	71·5	72·6	73·6	74·7	75·7	76·8	77·8	78·9	79·9
		$I/_Y$	12·3	12·5	12·7	12·95	13·15	13·4	13·65	13·9	14·1	14·35	14·55	14·8	15·05
7	·50	A		5·24	5·38	5·52	5·66	5·80	5·94	6·08	6·22	6·36	6·50	6·64	6·78
		I		97·8	99·4	101·0	102·6	104·2	105·7	107·3	108·8	110·4	111·9	113·4	115·0
		$I/_Y$		15·55	15·85	16·15	16·45	16·8	17·1	17·4	17·7	18·0	18·3	18·6	18·9
8	·52	A				5·94	6·10	6·26	6·42	6·58	6·74	6·90	7·06	7·22	7·38
		I				138·3	140·6	142·9	145·2	147·5	149·7	151·9	154·1	156·3	158·4
		$I/_Y$				19·65	20·05	20·40	20·8	21·15	21·55	21·95	22·35	22·75	23·15
9	·54	A				6·37	6·55	6·73	6·91	7·09	7·27	7·45	7·63	7·81	7·99
		I				183·0	186·0	189·5	192·5	196·0	199·0	202·0	205·0	208·0	210·5
		$I/_Y$				22·35	23·85	24·35	24·85	25·35	25·85	26·35	26·85	27·3	27·8
10	·56	A					6·99	7·19	7·39	7·59	7·79	7·99	8·19	8·39	8·59
		I					240·0	244·0	248·0	252·0	256·0	260·0	264·0	268·0	272·0
		$I/_Y$					28·0	28·6	29·2	29·8	30·35	30·9	31·5	32·1	32·7
12	·50	A					7·31	7·55	7·79	8·03	8·27	8·51	8·75	8·99	9·23
		I					348·0	354·5	361·0	368·0	375·0	381·5	388·0	394·5	401·0
		$I/_Y$					34·1	35·0	35·8	36·6	37·5	38·3	39·1	39·9	40·8
12	·60	A						8·12	8·36	8·60	8·84	9·08	9·32	9·56	9·80
		I						381·0	387·5	394·0	400·5	407·0	413·5	420·0	426·0
		$I/_Y$						38·0	38·8	39·6	40·45	41·3	42·15	43·0	43·75

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
			·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76
6	·48	A	6·29	6·41	6·53	6·65	6·77	6·89	7·01						
		I	81·0	82·1	83·2	84·3	85·4	86·6	87·7						
		$I/_Y$	15·3	15·55	15·8	16·0	16·25	16·5	16·75						
7	·50	A	6·92	7·06	7·20	7·34	7·48	7·62	7·76	7·90					
		I	116·5	118·0	119·5	121·0	122·4	123·8	125·2	126·6					
		$I/_Y$	19·2	19·5	19·8	20·1	20·4	20·7	21·0	21·3					
8	·52	A	7·54	7·70	7·86	8·02	8·18	8·34	8·50	8·66	8.82				
		I	160·5	162·6	164·7	166·8	168·9	170·9	172·9	174·9	176·9				
		$I/_Y$	23·45	23·85	24·25	24·7	25·05	25·4	25·8	26·2	26·5				
9	·54	A	8·17	8·35	8·53	8·71	8·89	9·07	9·25	9·43	9·61	9·79			
		I	213·5	216·5	219·5	222·5	225·0	228·0	230·5	233·5	236·0	239·0			
		$I/_Y$	28·25	28·7	29·2	29·7	30·15	30·6	31·05	31·5	32·0	32·5			
10	·56	A	8·79	8·99	9·19	9·39	9·59	9·79	9·99	10·19	10·39	10·59	10·79		
		I	276·0	280·0	284·0	288·0	291·5	295·0	298·5	302·0	305·5	309·0	312·0		
		$I/_Y$	33·3	33·9	34·5	35·1	35·65	36·2	36·75	37·3	37·85	38·4	38·9		
12	·50	A	9·47	9·71	9·95	10·19	10·43	10·67	10·91	11·15	11·39	11·63	11·87	12·11	12·35
		I	407·5	414·0	420·0	426·0	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	479·0
		$I/_Y$	41·6	42·4	43·2	44·0	44·8	45·6	46·35	47·1	47·9	48·7	49·5	50·25	51·0
12	·60	A	10·04	10·28	10·52	10·76	11·00	11·24	11·48	11·72	11·96	12·20	12·44	12·68	12·92
		I	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	480·0	486·0	491·5	497·0	502·5
		$I/_Y$	44·5	45·3	46·1	46·9	47·7	48·45	49·2	50·0	50·85	51·7	52·45	53·2	54·0

TABLE 56

(SEE CONTINUATION)

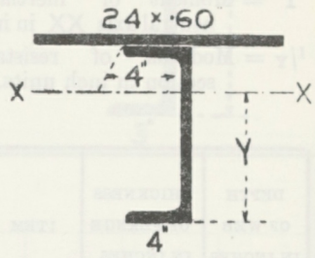
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channel in square inches.

I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating

I/Y = Modulus of resistance of section in inch units. }

CHANNELS HAVING 4-in. FLANGE



DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES									
			·38	·40	·42	·44	·46	·48	·50	·52	·54	·56
12	·60	A	8·97	9·21	9·45	9·69	9·93	10·17	10·41	10·65	10·89	11·13
		I	417·0	423·0	429·5	435·5	442·0	448·0	454·5	460·5	466·5	472·0
		I/Y	42·20	43·00	43·80	44·60	45·40	46·20	47·00	47·80	48·60	49·40
15	·62	A		10·55	10·85	11·15	11·45	11·75	12·05	12·35	12·65	12·95
		I		716·5	728·0	739·5	751·0	762·5	773·5	784·5	795·0	806·0
		I/Y		59·70	60·95	62·15	63·35	64·60	65·85	67·05	68·25	69·45
17	·68	A				12·36	12·70	13·04	13·38	13·72	14·06	14·40
		I				1020·5	1035·5	1050·5	1065·5	1080·5	1095·5	1110·0
		I/Y				77·05	78·55	80·05	81·60	83·10	84·60	86·10

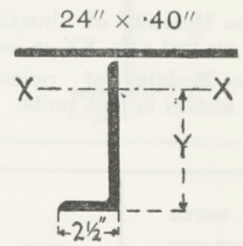
DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES									
			·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78
12	·60	A	11·37	11·61	11·85	12·09	12·33	12·57	12·81	13·05	13·29	13·53	13·77
		I	478·0	484·0	489·5	495·5	501·0	506·5	512·5	518·0	523·0	528·5	534·0
		I/Y	50·20	51·00	51·80	52·60	53·35	54·15	54·90	55·65	56·45	57·20	57·95
15	·62	A	13·25	13·55	13·85	14·15	14·45	14·75	15·05	15·35	15·65	15·95	16·25
		I	816·5	827·5	837·5	848·0	858·0	868·0	878·5	888·0	898·0	908·0	917·5
		I/Y	70·65	71·80	73·00	74·20	75·35	76·50	77·70	78·85	80·00	81·10	82·20
17	·68	A	14·74	15·08	15·42	15·76	16·10	16·44	16·78	17·12	17·46	17·80	18·14
		I	1125·0	1139·5	1154·0	1168·0	1182·5	1196·5	1210·5	1224·0	1237·5	1251·0	1264·5
		I/Y	87·55	89·00	90·50	92·00	93·45	94·90	96·35	97·80	99·25	100·65	102·05

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

INVERTED ANGLES

HAVING 2½-in. FLANGE



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·20	·22	·24	·26	·28	·30	·32	·34	·36
2½	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67
	I	4·2	4·5	4·9	5·2	5·5	5·8	6·0	6·3	6·5
	$I/_Y$	1·7	1·8	2·0	2·1	2·2	2·3	2·5	2·6	2·7
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85
	I	6·2	6·7	7·2	7·6	8·1	8·5	8·9	9·3	9·6
	$I/_Y$	2·1	2·3	2·4	2·6	2·8	2·9	3·1	3·2	3·4
3½	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03
	I		9·4	10·1	10·7	11·4	12·0	12·6	13·1	13·7
	$I/_Y$		2·8	3·0	3·2	3·4	3·6	3·8	4·0	4·2

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·38	·40	·42	·44	·46	·48	·50	·52	·54
2½	A	1·76	1·84	1·92	2·01	2·09	2·17	2·25		
	I	6·8	7·0	7·2	7·4	7·6	7·8	7·9		
	$I/_Y$	2·8	2·9	3·0	3·1	3·2	3·3	3·4		
3	A	1·95	2·04	2·13	2·23	2·32	2·41	2·50	2·59	2·68
	I	10·0	10·3	10·7	11·0	11·3	11·6	11·9	12·1	12·4
	$I/_Y$	3·5	3·7	3·8	4·0	4·1	4·2	4·3	4·4	4·6
3½	A	2·14	2·24	2·34	2·45	2·55	2·65	2·75	2·85	2·95
	I	14·2	14·7	15·1	15·5	16·0	16·4	16·8	17·1	17·5
	$I/_Y$	4·4	4·6	4·7	4·9	5·0	5·2	5·3	5·5	5·6

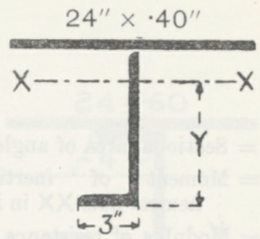
TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 3-in. FLANGE



A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units.
$I/_Y$ = Modulus of resistance of section in inch units.
} In conjunction with plating.

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·26	·28	·30	·32	·34	·36	·38	·40	·42
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34
	I	8·6	9·1	9·6	10·0	10·5	10·9	11·3	11·7	12·1
	$I/_Y$	3·0	3·2	3·4	3·6	3·7	3·9	4·1	4·2	4·4
3½	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55
	I	12·0	12·7	13·3	14·0	14·6	15·2	15·8	16·4	16·9
	$I/_Y$	3·6	3·9	4·1	4·3	4·5	4·7	5·0	5·2	5·4
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76
	I	16·3	17·1	17·9	18·8	19·6	20·4	21·2	22·0	22·7
	$I/_Y$	4·4	4·6	4·9	5·1	5·4	5·6	5·9	6·1	6·4
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18
	I	26·4	27·9	29·4	30·9	32·3	33·6	34·9	36·2	37·4
	$I/_Y$	5·7	6·1	6·5	6·9	7·3	7·6	8·0	8·3	8·7
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60
	I	40·0	42·4	44·6	46·8	48·9	50·9	52·8	54·7	56·6
	$I/_Y$	7·4	7·9	8·4	8·9	9·3	9·8	10·3	10·7	11·1

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·44	·46	·48	·50	·52	·54	·56	·58	·60
3	A	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	
	I	12·4	12·8	13·1	13·4	13·7	14·0	14·3	14·6	
	$I/_Y$	4·6	4·7	4·9	5·0	5·2	5·3	5·4	5·5	
3½	A	2·67	2·78	2·89	3·00	3·11	3·22	3·33	3·43	3·54
	I	17·4	17·9	18·4	18·9	19·3	19·7	20·1	20·5	20·8
	$I/_Y$	5·6	5·8	6·0	6·1	6·3	6·5	6·6	6·8	6·9
4	A	2·89	3·01	3·13	3·25	3·37	3·49	3·61	3·72	3·84
	I	23·4	24·1	24·8	25·4	26·0	26·5	27·1	27·6	28·1
	$I/_Y$	6·6	6·9	7·1	7·3	7·6	7·8	8·0	8·2	8·4
5	A	3·33	3·47	3·61	3·75	3·89	4·03	4·17	4·30	4·44
	I	38·6	39·8	40·9	41·9	42·9	43·9	44·8	45·8	46·7
	$I/_Y$	9·0	9·3	9·6	9·9	10·2	10·5	10·8	11·1	11·3
6	A	3·77	3·93	4·09	4·25	4·41	4·57	4·73	4·88	5·04
	I	58·4	60·2	62·0	63·6	65·1	66·6	68·2	69·7	71·0
	$I/_Y$	11·6	12·0	12·4	12·8	13·2	13·6	14·0	14·4	14·7

TABLE 56

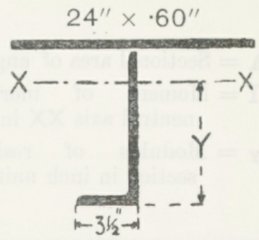
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 3½-in. FLANGE

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
3½	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	15·2	16·1	16·9	17·8	18·6	19·3	20·1	20·9	21·6	22·3	22·9	23·6
	$I/_Y$	4·4	4·6	4·9	5·2	5·4	5·7	5·9	6·2	6·4	6·7	6·9	7·1
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	20·0	21·1	22·2	23·3	24·3	25·4	26·4	27·4	28·4	29·4	30·4	31·3
	$I/_Y$	5·1	5·4	5·7	6·0	6·3	6·7	7·0	7·3	7·5	7·8	8·1	8·4
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	32·3	34·2	36·0	37·9	39·7	41·4	43·1	44·7	46·3	47·8	49·2	50·7
	$I/_Y$	6·7	7·2	7·6	8·0	8·5	8·9	9·3	9·7	10·1	10·5	10·8	11·2
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			54·3	57·0	59·6	62·2	64·6	67·0	69·3	71·6	73·9	76·1
	$I/_Y$			9·7	10·2	10·7	11·2	11·8	12·3	12·8	13·3	13·8	14·3
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					84·3	88·0	91·5	95·0	98·5	101·7	105·0	108·1
	$I/_Y$					13·3	13·9	14·6	15·3	15·9	16·5	17·2	17·8

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
3½	A	3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07					
	I	24·2	24·8	25·3	25·9	26·4	27·0	27·5	28·0					
	$I/_Y$	7·3	7·6	7·8	8·0	8·2	8·4	8·6	8·8					
4	A	3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51				
	I	32·2	33·0	33·7	34·5	35·2	36·0	36·7	37·3	37·8				
	$I/_Y$	8·7	8·9	9·2	9·5	9·7	9·9	10·1	10·4	10·6				
5	A	4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46		
	I	52·2	53·6	54·9	56·3	57·5	58·8	60·0	61·2	62·4	63·5	64·5		
	$I/_Y$	11·6	12·0	12·3	12·7	13·0	13·3	13·7	14·0	14·4	14·7	15·0		
6	A	4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48
	I	78·3	80·5	82·5	84·5	86·5	88·4	90·3	92·0	93·7	95·4	97·1	98·6	100·2
	$I/_Y$	14·8	15·3	15·7	16·2	16·7	17·1	17·6	18·0	18·4	18·8	19·2	19·6	20·0
7	A	5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22
	I	111·2	114·2	117·0	119·8	122·5	125·2	127·8	130·4	132·8	135·2	137·7	140·0	142·2
	$I/_Y$	18·3	18·9	19·5	20·1	20·6	21·2	21·7	22·3	22·8	23·3	23·8	24·3	24·8

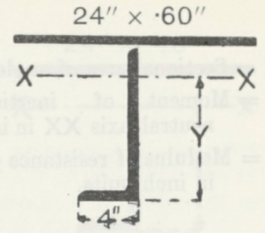
TABLE 56
(CONCLUDED)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 4-in. FLANGE

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
4	A	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47	3·61	3·75	3·89	4·03
	I	24·4	25·7	26·9	28·1	29·3	30·4	31·4	32·4	33·3	34·3	35·2	36·1	37·0
	$I/_Y$	6·4	6·7	7·1	7·4	7·8	8·1	8·4	8·7	9·0	9·3	9·6	9·9	10·2
5	A	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93	4·09	4·25	4·41	4·57
	I	39·0	41·0	43·0	44·9	46·7	48·5	50·2	51·9	53·5	55·1	56·7	58·2	59·6
	$I/_Y$	8·3	8·8	9·2	9·7	10·1	10·6	11·0	11·5	11·9	12·3	12·7	13·2	13·6
6	A			3·38	3·47	3·66	3·84	4·02	4·21	4·39	4·57	4·75	4·93	5·11
	I			63·2	66·0	68·8	71·6	74·3	76·8	79·3	81·7	84·0	86·4	88·6
	$I/_Y$			11·5	12·1	12·7	13·3	13·8	14·4	15·0	15·5	16·1	16·6	17·1
8	A						4·64	4·86	5·09	5·31	5·53	5·75	5·97	6·19
	I						138·0	142·7	147·3	151·9	156·4	160·8	165·0	169·3
	$I/_Y$						19·8	20·6	21·4	22·2	23·0	23·8	24·6	25·4
9	A							5·28	5·53	5·77	6·01	6·25	6·49	6·73
	I							185·0	191·3	197·6	203·6	209·6	215·6	221·4
	$I/_Y$							24·1	25·1	26·1	27·1	28·1	29·0	30·0
10	A								5·97	6·23	6·49	6·75	7·01	7·27
	I								243·7	251·5	259·2	266·8	274·1	281·3
	$I/_Y$								29·1	30·2	31·3	32·4	33·6	34·7

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
		·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78	·80
4	A	4·17	4·30	4·44	4·58	4·71	4·84							
	I	37·9	38·7	39·6	40·4	41·3	42·1							
	$I/_Y$	10·5	10·8	11·1	11·4	11·7	12·0							
5	A	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81					
	I	61·1	62·5	63·9	65·2	66·5	67·7	68·9	70·0					
	$I/_Y$	14·0	14·4	14·7	15·1	15·5	15·8	16·2	16·5					
6	A	5·29	5·46	5·64	5·82	5·99	6·16	6·34	6·51	6·68	6·85			
	I	90·7	92·8	94·8	96·8	98·7	100·6	102·4	104·1	105·8	107·5			
	$I/_Y$	17·6	18·1	18·6	19·1	19·6	20·0	20·5	20·9	21·3	21·8			
8	A	6·41	6·62	6·84	7·06	7·27	7·48	7·70	7·91	8·12	8·33	8·54	8·75	8·96
	I	173·5	177·5	181·5	185·3	189·0	192·6	196·2	199·6	202·9	206·0	209·0	212·0	214·8
	$I/_Y$	26·2	26·9	27·7	28·5	29·2	29·9	30·6	31·3	32·0	32·6	33·2	33·8	34·4
9	A	6·97	7·20	7·44	7·68	7·91	8·14	8·38	8·61	8·84	9·07	9·30	9·53	9·76
	I	226·9	232·2	237·5	242·5	247·5	252·2	256·8	261·3	265·7	270·0	274·3	278·5	282·7
	$I/_Y$	30·9	31·8	32·7	33·6	34·4	35·3	36·2	37·0	37·8	38·6	39·4	40·2	41·0
10	A	7·53	7·78	8·04	8·30	8·55	8·80	9·06	9·31	9·56	9·81	10·06	10·31	10·56
	I	288·4	295·3	302·0	308·7	315·3	321·6	327·8	333·8	339·6	345·1	350·3	355·3	360·0
	$I/_Y$	35·8	36·9	38·0	39·0	40·1	41·1	42·1	43·1	44·0	45·0	45·9	46·7	47·5

TABLE 60

BOTTOM AND SIDE TRANSVERSES
VERTICAL WEBS ON LONGITUDINAL BULKHEADS
CONTINUOUS CENTRE LINE BOTTOM GIRDER

SPAN	NUMERAL															
	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500
Feet	DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES															
8	33×·38 1·4	33×·38 1·4	34×·38 1·5	34×·40 1·6	35×·40 1·7	35×·42 1·8	36×·42 1·9	36×·44 2·0	36×·44 2·1	37×·44 2·2	38×·46 2·4	40×·46 2·5				
10	34×·38 1·5	34×·38 1·7	35×·40 1·8	35×·40 1·9	36×·40 2·0	36×·42 2·4	37×·42 2·8	37×·44 3·0	37×·44 3·2	38×·44 3·3	40×·46 3·4	42×·46 3·4				
12	35×·38 2·5	36×·40 2·9	37×·40 3·2	37×·40 3·6	38×·42 3·9	38×·42 4·3	39×·42 4·6	39×·44 5·0	40×·44 5·3	41×·44 5·3	43×·46 5·3	45×·46 5·3	46×·46 5·3			
14	37×·40 4·1	38×·40 4·6	39×·40 5·0	40×·40 5·6	40×·42 6·0	41×·42 6·5	41×·42 6·9	42×·44 7·3	43×·44 7·7	45×·44 7·8	47×·46 7·8	48×·46 7·9	49×·46 7·9	50×·46 7·9		
16	39×·40 5·7	40×·40 6·4	41×·42 7·0	42×·42 7·5	43×·42 8·0	44×·42 8·6	45×·44 9·0	46×·44 9·5	47×·44 10·0	48×·46 10·2	50×·46 10·4	51×·46 10·6	53×·46 10·6	54×·48 10·6	56×·48 10·6	59×·48 10·6
18	42×·42 7·2	43×·42 8·0	44×·42 8·7	45×·42 9·5	46×·42 10·2	47×·44 10·8	48×·44 11·4	49×·44 12·0	50×·46 12·6	51×·46 12·8	53×·46 12·9	55×·46 12·9	57×·48 13·0	59×·48 13·0	60×·48 13·0	62×·48 13·0
20		45×·42 9·0	46×·42 9·4	47×·44 10·1	48×·44 10·9	50×·44 11·5	51×·44 12·0	52×·46 12·6	53×·46 13·1	54×·46 13·5	56×·48 13·8	58×·48 14·0	59×·48 14·2	61×·48 14·2	63×·48 14·3	64×·48 14·3
22			49×·44 10·0	50×·44 10·6	51×·44 11·3	53×·46 11·8	54×·46 12·3	55×·46 13·0	56×·46 13·6	57×·48 14·1	59×·48 14·6	61×·48 14·9	62×·48 15·2	64×·48 15·4	65×·50 15·5	66×·50 15·5
24				53×·46 10·8	54×·46 11·4	55×·46 12·0	57×·48 12·6	58×·48 13·4	59×·48 14·0	60×·48 14·8	61×·48 15·4	63×·50 15·8	64×·50 16·2	66×·50 16·5	67×·50 16·7	68×·50 16·8
26				56×·48 10·8	57×·48 11·4	58×·48 12·0	60×·48 12·9	61×·50 13·8	62×·50 14·5	63×·50 15·4	64×·50 16·1	65×·50 16·7	66×·50 17·3	67×·50 17·6	69×·50 17·9	70×·50 18·1
28					60×·50 11·5	61×·50 12·1	62×·50 13·2	63×·50 14·1	64×·50 15·0	65×·50 16·0	66×·50 16·8	67×·50 17·6	68×·50 18·3	69×·50 18·8	70×·50 19·2	72×·50 19·3
30						63×·50 12·2	64×·50 13·6	65×·50 14·7	66×·50 15·7	67×·50 16·7	68×·50 17·6	69×·50 18·5	70×·50 19·3	71×·50 19·9	72×·50 20·5	74×·50 20·5
32							66×·50 13·9	67×·50 15·2	68×·50 16·4	69×·50 17·4	70×·50 18·3	71×·50 19·4	72×·50 20·5	73×·50 21·0	74×·50 21·5	76×·50 21·7
34								69×·50 15·8	70×·50 17·1	71×·50 18·1	72×·50 19·0	73×·50 20·3	74×·50 21·4	75×·50 22·0	76×·50 22·5	78×·50 22·8
36									72×·50 17·7	73×·50 18·7	74×·50 19·7	75×·50 21·2	76×·50 22·3	77×·50 23·0	78×·50 23·6	80×·50 23·8

NOTES.—TABLE 60

1. **Numeral** is to be calculated as follows :—

(*a*) FOR BOTTOM TRANSVERSES

Numeral = s × D

Where s = spacing of transverses, in feet

D = Moulded depth of ship, in feet.

(*b*) FOR CENTRE LINE BOTTOM GIRDERS SUPPORTING TRANSVERSES

Numeral = b × D

Where b = half breadth of centre tank, in feet

D = Moulded depth of ship, in feet.

(*c*) FOR SIDE TRANSVERSES AND LONGITUDINAL BULKHEAD VERTICAL WEBS SUPPORTING LONGITUDINALS OR HORIZONTAL GIRDERS

Numeral = 1·4 s × h

Where s = spacing of transverses, in feet

h = vertical distance in feet from the midpoint of the span to the deck at side, amidships.

Side transverses or webs which are supported by cross ties are to be in accordance with Table 63.

TABLE 60

BOTTOM AND SIDE TRANSVERSES

VERTICAL WEBS ON LONGITUDINAL BULKHEADS

CONTINUOUS CENTRE LINE BOTTOM GIRDER

NUMERAL															SPAN
520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	
DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES															Feet
															8
															10
															12
															14
															16
64×·48 13·0															18
66×·50 14·3	68×·50 14·3	70×·50 14·3	72×·50 14·3	74×·50 14·3	76×·50 14·3	77×·50 14·3	79×·50 14·3	80×·50 14·3	81×·50 14·3	82×·52 14·3					20
68×·50 15·6	70×·50 15·6	72×·50 15·6	74×·50 15·6	76×·50 15·6	78×·50 15·6	79×·50 15·6	81×·50 15·6	82×·50 15·6	84×·52 15·6	85×·52 15·6	87×·52 15·6	89×·52 15·6			22
70×·50 16·9	72×·50 16·9	74×·50 16·9	76×·50 16·9	78×·50 16·9	79×·50 16·9	81×·50 16·9	83×·50 16·9	84×·52 16·9	86×·52 16·9	88×·52 16·9	90×·52 16·9	92×·52 16·9	94×·52 16·9	96×·52 16·9	24
72×·50 18·1	74×·50 18·1	76×·50 18·1	78×·50 18·1	80×·50 18·1	82×·50 18·1	84×·50 18·1	86×·52 18·1	87×·52 18·1	89×·52 18·1	91×·52 18·1	93×·52 18·1	94×·52 18·1	96×·52 18·1	98×·52 18·1	26
74×·50 19·4	76×·50 19·4	78×·50 19·4	80×·50 19·4	82×·50 19·4	84×·50 19·4	86×·52 19·4	88×·52 19·4	90×·52 19·4	92×·52 19·4	94×·52 19·4	95×·52 19·4	97×·52 19·4	99×·52 19·4	100×·52 19·4	28
76×·50 20·6	78×·50 20·6	80×·50 20·7	82×·50 20·7	84×·50 20·7	86×·52 20·7	88×·52 20·7	90×·52 20·7	92×·52 20·7	94×·52 20·7	96×·52 20·7	97×·52 20·7	99×·52 20·7	101×·52 20·7	103×·52 20·7	30
78×·50 21·7	80×·50 21·8	82×·50 21·9	84×·50 21·9	86×·52 21·9	88×·52 21·9	90×·52 21·9	92×·52 21·9	94×·52 21·9	96×·52 21·9	98×·52 21·9	100×·52 21·9	102×·52 21·9	104×·52 21·9	106×·52 21·9	32
80×·50 23·0	82×·50 23·1	84×·50 23·1	86×·52 23·1	88×·52 23·1	90×·52 23·1	92×·52 23·1	94×·52 23·1	96×·52 23·1	98×·52 23·1	100×·52 23·1	102×·52 23·1	104×·52 23·1	106×·52 23·1	109×·52 23·1	34
82×·50 24·0	84×·50 24·2	86×·52 24·3	88×·52 24·3	90×·52 24·3	92×·52 24·3	94×·52 24·3	96×·52 24·3	98×·52 24·3	100×·52 24·3	102×·52 24·3	104×·52 24·3	106×·52 24·3	109×·52 24·3	112×·52 24·3	36

NOTES.—TABLE 60 (*concluded*)

2. **Span** is the distance in feet from "Span Point" to "Span Point" (*see* Sketch following Table 77).

3. **Depth** given in the Table is the depth of the web plate.

4. Vertical webs on longitudinal bulkheads may have web plates 10 per cent less in thickness than required by the Table.

5. **Minimum requirements.**—(*a*) For bottom transverses the depth of web is not to be less than ·055 B, where B is the moulded breadth in feet, modified at the rate of 5 per cent per foot of difference between the spacing of the transverses and 10 feet.

(*b*) No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

6. This Table does not apply to corrugated bulkheads.

TABLE 61

DECK TRANSVERSES

SPAN	NUMERAL							
	40	44	48	52	56	60	64	68
Feet	DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES							
8	24 × ·40 2·5	25 × ·40 2·6	26 × ·40 2·7	27 × ·41 2·8	27 × ·41 2·9	28 × ·41 3·0	29 × ·42 3·1	30 × ·42 3·2
9	25 × ·40 2·6	26 × ·40 2·7	27 × ·40 2·8	28 × ·41 2·9	28 × ·41 3·0	29 × ·41 3·1	30 × ·42 3·2	31 × ·42 3·3
10	25 × ·40 2·8	26 × ·40 2·9	27 × ·40 3·0	28 × ·41 3·1	29 × ·41 3·2	29 × ·41 3·3	30 × ·42 3·4	31 × ·42 3·5
11	26 × ·40 2·9	27 × ·40 3·0	28 × ·40 3·1	28 × ·41 3·2	29 × ·41 3·3	30 × ·41 3·4	30 × ·42 3·5	31 × ·42 3·6
12	26 × ·40 3·0	27 × ·40 3·1	28 × ·40 3·3	29 × ·41 3·4	30 × ·41 3·5	31 × ·41 3·6	31 × ·42 3·7	32 × ·42 3·8
13	27 × ·40 3·2	28 × ·40 3·3	29 × ·40 3·4	30 × ·41 3·5	31 × ·41 3·7	31 × ·41 3·8	32 × ·42 3·9	33 × ·42 4·0
14	27 × ·40 3·4	28 × ·40 3·5	29 × ·40 3·6	30 × ·41 3·7	31 × ·41 3·9	32 × ·41 4·0	33 × ·42 4·1	34 × ·42 4·2
15	27 × ·40 3·6	28 × ·40 3·7	29 × ·40 3·9	30 × ·41 4·0	31 × ·41 4·1	32 × ·41 4·2	33 × ·42 4·3	34 × ·42 4·4
16	28 × ·40 3·9	29 × ·40 4·0	30 × ·40 4·1	31 × ·41 4·2	32 × ·41 4·3	33 × ·41 4·4	34 × ·42 4·5	35 × ·42 4·6

NOTES.—TABLE 61

1. **Numeral** is to be calculated as follows :—

FOR CENTRE TANK

(*a*) Numeral = ·015 s × L

FOR WING TANKS

(*b*) Numeral = ·011 s × L

Where s = Spacing of transverse, in feet

L = Length of ship, in feet.

2. **Span** is the distance in feet from "Span Point" to "Span Point" of the transverse (*see* Sketch, following Table 77).

TABLE 61

DECK TRANSVERSES

NUMERAL								SPAN
72	76	80	84	88	92	96	100	
DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES								Feet
30 × ·42 3·3	31 × ·43 3·4	31 × ·43 3·5	32 × ·43 3·7	33 × ·44 3·8	34 × ·44 3·9	34 × ·44 4·0	35 × ·44 4·1	8
31 × ·42 3·5	32 × ·43 3·6	32 × ·43 3·7	33 × ·43 3·9	34 × ·44 3·9	35 × ·44 4·1	35 × ·44 4·2	36 × ·44 4·3	9
32 × ·42 3·6	32 × ·43 3·7	33 × ·43 3·9	33 × ·43 4·0	34 × ·44 4·1	35 × ·44 4·3	36 × ·44 4·4	36 × ·44 4·5	10
32 × ·42 3·8	33 × ·43 3·9	33 × ·43 4·1	34 × ·43 4·2	35 × ·44 4·3	36 × ·44 4·5	37 × ·44 4·6	37 × ·44 4·8	11
33 × ·42 4·0	34 × ·43 4·1	34 × ·43 4·3	35 × ·43 4·4	36 × ·44 4·6	37 × ·44 4·7	37 × ·44 4·8	38 × ·44 5·0	12
34 × ·42 4·1	35 × ·43 4·3	35 × ·43 4·5	36 × ·43 4·6	36 × ·44 4·8	37 × ·44 4·9	38 × ·44 5·1	39 × ·44 5·2	13
35 × ·42 4·3	36 × ·43 4·5	36 × ·43 4·7	37 × ·43 4·8	38 × ·44 5·0	38 × ·44 5·1	39 × ·44 5·3	39 × ·44 5·5	14
35 × ·42 4·5	36 × ·43 4·7	37 × ·43 4·9	38 × ·43 5·0	39 × ·44 5·2	39 × ·44 5·3	40 × ·44 5·5	40 × ·44 5·7	15
36 × ·42 4·8	37 × ·43 4·9	38 × ·43 5·1	39 × ·43 5·3	40 × ·44 5·4	40 × ·44 5·6	41 × ·44 5·7	41 × ·44 5·9	16

NOTES.—TABLE 61 *(concluded)*

3. **Depth** given in the Table is the depth of the web plate.

4. **Minimum requirements.**—(*a*) The depth of web is not to be less than ·04 B, where B is the moulded breadth in feet, modified at the rate of 5 per cent per foot of difference between the spacing of the transverses and 10 feet.

(*b*) No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

TABLE 62

INTERCOSTAL CENTRE LINE BOTTOM GIRDER

B × D	GIRDER DEPTH AND THICKNESS	FACE AREA
	Inches	Square inches
1000	35 × ·38	3·5
1500	41 × ·40	3·8
2000	47 × ·42	4·1
2500	53 × ·44	4·4
3000	60 × ·46	4·7
3500	68 × ·48	5·0

NOTES.—TABLE 62

1. B and D are the moulded breadth and depth of the ship, in feet.

2. **Correction for spacing of transverses.** The depth of the girder is to be modified at the rate of 5 per cent per foot of difference between the spacing of transverses and 10 feet. The face area is to remain unaltered.

3. Depth of girder need not exceed depth of the bottom transverses, but if this is less than the depth derived from the Table the face area is to be suitably increased.

4. **Minimum thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

TABLE 63

SIDE TRANSVERSES AND VERTICAL WEBS ON LONGITUDINAL BULKHEADS, SUPPORTED BY TWO CROSS TIES

DEPTH D	DEPTH OF WEB		THICKNESS OF SIDE TRANSVERSE WEB PLATE	FACE AREA
	TRANSVERSE FRAMING	LONGITUDINAL FRAMING		
Feet	Inches	Inches	Inches	Square inches
26		20	·38	2·0
28		22	·40	2·2
30	20	24	·40	2·4
32	22	26	·42	2·6
34	24	28	·42	2·8
36	28	32	·44	2·8
38	32	36	·44	3·0
40	36	40	·46	3·0
42	40	44	·46	3·0
44	44	48	·48	3·0
46	48	52	·48	3·0

NOTES.—TABLE 63

1. **Depth of web** given in the Table is the depth of the web plate.

2. **Correction for spacing of transverses.**—If the spacing of transverses differs from 10 feet the depth of web is to be modified at the rate of 5 per cent for every foot of difference. The face area and the thickness of web are to correspond with the corrected depth.

3. **Correction for number of cross ties.**—When one cross tie is fitted the depth of the web after correction by note 2 if necessary, is to be increased by 15 per cent; when there are three cross ties the depth may be reduced by 10 per cent.

4. **Webs on longitudinal bulkheads.**—Webs on longitudinal bulkheads may be 10 per cent less in thickness than required for side transverses.

5. The scantlings of side transverses and vertical webs on longitudinal bulkheads supporting longitudinals or horizontal girders, and not themselves supported by cross ties, are not to be less than required by Table 60 and associated notes.

6. **Minimum thicknesses.**—No part of the side transverses or vertical webs is to be less in thickness than required by Table 77.

7. This Table does not apply to corrugated bulkheads.

TABLE 64

SIDE STRINGERS
HORIZONTAL GIRDERS ON LONGITUDINAL AND TRANSVERSE BULKHEADS
VERTICAL WEBS ON TRANSVERSE BULKHEADS

SPAN	NUMERAL								
	100	120	140	160	180	200	220	240	260
Feet	DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES								
8	23 × ·38 1·2	23 × ·38 1·2	23 × ·38 1·3	24 × ·40 1·4	24 × ·40 1·4	24 × ·40 1·5	25 × ·40 1·5	26 × ·40 1·6	27 × ·42 1·7
9	24 × ·38 1·4	24 × ·38 1·5	24 × ·40 1·6	25 × ·40 1·7	25 × ·40 1·9	25 × ·40 2·1	26 × ·40 2·2	27 × ·40 2·3	28 × ·42 2·4
10	26 × ·38 1·6	26 × ·40 1·6	26 × ·40 1·8	27 × ·40 2·0	27 × ·40 2·2	27 × ·40 2·5	28 × ·40 2·7	29 × ·42 2·9	30 × ·42 3·1
11	27 × ·40 1·7	27 × ·40 1·7	27 × ·40 1·9	28 × ·40 2·1	28 × ·40 2·4	28 × ·42 2·8	29 × ·42 3·1	30 × ·42 3·4	31 × ·42 3·7
12	29 × ·40 1·9	29 × ·40 1·9	29 × ·40 2·0	30 × ·42 2·3	30 × ·42 2·7	30 × ·42 3·1	31 × ·42 3·5	32 × ·42 3·9	33 × ·42 4·3
14	32 × ·42 2·0	32 × ·42 2·0	33 × ·42 2·2	33 × ·42 2·7	34 × ·42 3·2	34 × ·42 3·8	35 × ·42 4·3	36 × ·44 4·8	37 × ·44 5·3
16	36 × ·42 2·0	36 × ·42 2·0	37 × ·42 2·4	37 × ·42 3·0	38 × ·42 3·7	38 × ·42 4·5	39 × ·44 5·3	40 × ·44 5·9	41 × ·44 6·4
18	40 × ·44 2·1	40 × ·44 2·1	41 × ·44 2·6	41 × ·44 3·4	42 × ·44 4·2	42 × ·44 5·0	43 × ·44 5·9	44 × ·44 6·7	45 × ·44 7·5
20	45 × ·44 2·2	45 × ·44 2·2	46 × ·44 2·8	46 × ·44 3·8	47 × ·44 4·8	47 × ·44 5·7	48 × ·44 6·6	49 × ·44 7·5	50 × ·46 8·4
22	49 × ·46 2·4	49 × ·46 2·4	50 × ·46 3·0	50 × ·46 4·2	51 × ·46 5·4	51 × ·46 6·4	52 × ·46 7·4	53 × ·46 8·4	54 × ·46 9·4
24	54 × ·48 2·6	54 × ·48 2·7	55 × ·48 3·2	55 × ·48 4·6	56 × ·48 6·0	56 × ·48 7·2	57 × ·48 8·4	58 × ·48 9·5	59 × ·48 10·6
26		57 × ·50 2·9	57 × ·50 3·4	58 × ·50 5·1	59 × ·50 6·7	59 × ·50 8·1	60 × ·50 9·5	61 × ·50 10·8	62 × ·50 12·1
28		61 × ·50 3·1	61 × ·50 3·6	61 × ·50 5·7	62 × ·50 7·7	62 × ·50 9·3	63 × ·50 10·8	64 × ·50 12·2	65 × ·50 13·7
30		63 × ·50 3·2	63 × ·50 3·8	64 × ·50 6·5	64 × ·50 9·2	65 × ·50 11·1	65 × ·50 12·6	66 × ·50 14·1	67 × ·50 15·7
32		66 × ·50 3·3	66 × ·50 3·9	67 × ·50 7·4	67 × ·50 10·6	68 × ·50 12·8	68 × ·50 14·4	69 × ·50 16·0	70 × ·50 17·7

NOTES.—TABLE 64

1. **Numeral** is to be calculated as follows :—

(*a*) FOR LOWER STRINGERS AND HORIZONTAL GIRDERS AND FOR VERTICAL WEBS

Numeral = b × h

Where b = width in feet of plating supported.

For lower side stringers or girders b is to be taken as half the distance between the next stringer or girder and the base line.

h = Vertical distance in feet from the mid-point of the span to the highest point of the tank, excluding the hatchway.

Where vertical webs to transverse bulkheads other than webs at the centre line are attached to continuous girders at the bottom and deck thus forming a ring system of structure, Numeral = ·8b × h.

(*b*) FOR MIDDLE OR SINGLE STRINGERS AND GIRDERS

Numeral = b × h

(*c*) FOR UPPER STRINGERS AND GIRDERS

Numeral = 1·2 b × h

TABLE 64

SIDE STRINGERS
HORIZONTAL GIRDERS ON LONGITUDINAL AND TRANSVERSE BULKHEADS
VERTICAL WEBS ON TRANSVERSE BULKHEADS

NUMERAL									SPAN
280	300	320	340	360	380	400	420	440	
DEPTH AND THICKNESS OF WEB IN INCHES FACE AREA IN SQUARE INCHES									Feet
27 × ·42 1·7	28 × ·42 1·8	29 × ·42 1·8	29 × ·42 1·9	30 × ·42 1·9	31 × ·44 2·0	32 × ·44 2·0	32 × ·44 2·1	33 × ·44 2·2	8
28 × ·42 2·6	29 × ·42 2·6	30 × ·42 2·7	30 × ·44 2·8	31 × ·44 2·8	32 × ·44 2·9	33 × ·44 2·9	34 × ·44 2·9	35 × ·44 2·9	9
30 × ·42 3·3	31 × ·42 3·4	32 × ·44 3·5	32 × ·44 3·6	33 × ·44 3·7	34 × ·44 3·8	35 × ·44 3·8	36 × ·44 3·9	37 × ·44 3·9	10
31 × ·42 4·0	32 × ·44 4·2	33 × ·44 4·3	34 × ·44 4·4	35 × ·44 4·5	36 × ·44 4·6	37 × ·44 4·7	38 × ·44 4·8	39 × ·44 4·8	11
33 × ·44 4·7	34 × ·44 5·0	35 × ·44 5·2	36 × ·44 5·3	37 × ·44 5·4	38 × ·44 5·5	39 × ·44 5·6	40 × ·46 5·7	41 × ·46 5·7	12
37 × ·44 5·8	38 × ·44 6·3	39 × ·44 6·6	40 × ·44 6·8	41 × ·46 7·0	42 × ·46 7·2	43 × ·46 7·4	44 × ·46 7·6	45 × ·46 7·7	14
41 × ·44 7·1	42 × ·44 7·7	43 × ·46 8·1	44 × ·46 8·4	45 × ·46 8·7	46 × ·46 9·0	47 × ·46 9·4	48 × ·46 9·7	49 × ·46 9·9	16
45 × ·46 8·2	46 × ·46 8·9	47 × ·46 9·5	48 × ·46 10·0	49 × ·46 10·5	50 × ·46 11·0	51 × ·48 11·4	52 × ·48 11·7	53 × ·48 11·9	18
50 × ·46 9·3	51 × ·46 10·1	52 × ·46 10·8	53 × ·48 11·5	54 × ·48 12·2	55 × ·48 12·8	56 × ·48 13·4	57 × ·48 13·9	58 × ·48 14·3	20
54 × ·46 10·4	55 × ·48 11·3	56 × ·48 12·1	57 × ·48 12·9	58 × ·48 13·7	59 × ·48 14·5	60 × ·48 15·3	61 × ·50 16·0	62 × ·50 16·6	22
59 × ·48 11·6	60 × ·48 12·5	60 × ·48 13·5	61 × ·50 14·5	62 × ·50 15·4	63 × ·50 16·3	64 × ·50 17·2	65 × ·50 18·0	66 × ·50 18·7	24
62 × ·50 13·4	63 × ·50 14·5	63 × ·50 15·7	64 × ·50 16·4	65 × ·50 18·0	66 × ·50 19·0	67 × ·50 19·7	68 × ·50 20·5	69 × ·50 21·5	26
65 × ·50 15·2	66 × ·50 16·5	67 × ·50 17·7	68 × ·50 19·0	69 × ·50 20·0	70 × ·50 21·5	71 × ·50 22·5	72 × ·50 23·0	73 × ·50 24·0	28
68 × ·50 17·3	69 × ·50 18·7	70 × ·50 20·0	71 × ·50 21·0	72 × ·50 23·0	73 × ·50 24·0	74 × ·50 25·0	75 × ·50 26·0	76 × ·50 27·0	30
71 × ·50 19·4	72 × ·50 21·0	73 × ·50 22·5	74 × ·50 23·5	75 × ·50 25·5	76 × ·50 26·5	77 × ·50 27·5	78 × ·50 29·0	79 × ·50 30·0	32

NOTES.—TABLE 64 *(concluded)*

2. **Long tanks.**—If the length of tank exceeds 40 feet the Numeral for use on transverse bulkheads is to be increased in direct proportion.

3. **Span** is the distance in feet from "Span Point" to "Span Point" (*see* Sketch, following Table 77). For side stringers and horizontal girders on longitudinal bulkheads the span is not to be taken as less than 10 feet.

4. **Depth** given in the Table is the depth of the web plate.

5. **Side stringers** are to have web plates 5 per cent thicker than required by the Table.

6. **Minimum thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

7. This Table does not apply to corrugated bulkheads.

TABLE 65

CENTRE LINE DECK GIRDER

Length of Tank 40 feet

	NUMERAL	40	50	60	70	80	90	100	110	120	130	140	150	160	170
GIRDER	DEPTH Inches	53	53	54	54	55	56	58	60	62	64	66	69	72	75
	FACE AREA Square inches	1·4	1·8	2·2	2·6	3·2	3·8	4·5	5·0	5·0	5·5	5·5	6·0	6·0	6·5

NOTES.—TABLE 65

1. **Numeral** is to be calculated as follows :—

Numeral = ·015 b × L (*See* D 201).

Where b = Half-breadth of centre tank, in feet.

L = Length of ship, in feet.

2. **Depth** given in the Table is the depth of web plate.

3. **Thickness** of the web plate is to be the same as the thickness of the deck transverses.

4. **Correction for length of tank.**—If the length of tank differs from 40 feet the depth of web is to be modified at the rate of 2 inches for every 5 feet of difference. The face area is to correspond with the corrected depth.

5. **Minimum thicknesses.**—No part of the structure within cargo tanks and cofferdams is to be less in thickness than required by Table 77.

TABLE 66

CROSS TIES IN WING TANKS

NUMERAL	SECTIONAL AREA OF CROSS TIE
	Square inches
5	12
10	15
15	18
20	20
25	22
30	24

NOTES.—TABLE 66

1. **Numeral** is to be calculated as follows :—

$$\text{Numeral} = \frac{l \times s \times h}{100}$$

Where l = Vertical spacing of cross ties in feet.

For the lower cross tie l is to be taken as half the distance between the next cross tie and the base line.

For the uppermost cross tie l is to be taken as half the distance from the next cross tie to the deck at side.

s = Spacing of transverses, in feet.

h = Vertical distance in feet from the cross tie to the deck at side, amidships.

2. **Minimum thicknesses.**—No part of the cross tie is to be less in thickness than required by Table 77.

BOTTOM & DECK LONGITUDINALS

Spaced 30 inches apart and having a span of 10 feet

LENGTH L	MODULUS OF LONGITUDINALS	
	BOTTOM	DECK
Feet	Inches^3	Inches^3
240	37·3	10·8
250	38·7	10·9
260	40·1	11·0
270	41·5	11·1
280	42·8	11·2
290	44·2	11·3
300	45·6	11·4
310	46·9	11·7
320	48·2	11·9
330	49·5	12·2
340	50·9	12·4
350	52·2	12·7
360	53·5	13·0
370	54·8	13·3
380	56·1	13·6
390	57·5	14·0
400	58·8	14·3
410	60·2	14·7
420	61·7	15·1
430	63·2	15·5
440	64·7	15·9
450	66·2	16·3
460	67·7	16·9
470	69·1	17·4
480	70·6	17·9
490	72·1	18·5
500	73·6	19·0
510	75·0	19·8
520	76·5	20·6
530	78·0	21·3
540	79·4	22·1
550	80·9	22·9
560	82·3	24·0
570	83·8	25·2
580	85·3	26·3
590	86·7	27·4
600	88·2	28·6
610	89·6	29·5
620	91·1	30·4

NOTES.—TABLE 67

1. **Span** is to be measured from transverse to transverse or from transverse to the " span point " (*see* Sketch following Table 77) of the end connection.

2. **Corrections to modulus of longitudinals.**

FOR SPAN :

If the span is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than 10 feet, modulus of longitudinals to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of $\begin{matrix}20 \text{ per cent}\\15 \text{ per cent}\end{matrix}$ per foot of difference ; the modulus is not to be less than that required for an 8 feet spacing of transverses.

FOR SPACING OF LONGITUDINALS :

If the spacing of longitudinals differs from 30 inches, the modulus is to be modified in direct proportion.

3. For minimum thickness of longitudinals *see* Table 77.

4. Particulars of sections and moduli are given in Table 56.

TABLE 68

SI

Spaced 30 inches ap

DEPTH	HEAD—FEET																		
D	Not exceeding 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Feet	<— Modulus—Inches³																		
16	10·4	10·9	11·5	12·5	13·6	14·7	15·9	17·1	18·3										
17	10·6	11·0	11·5	12·6	13·6	14·8	16·0	17·1	18·3	19·4									
18	10·8	11·1	11·5	12·6	13·7	14·9	16·1	17·2	18·4	19·5	20·5								
19	11·0	11·2	11·5	12·6	13·7	15·0	16·2	17·3	18·5	19·6	20·7	21·7							
20	11·2	11·3	11·5	12·7	13·8	15·1	16·4	17·5	18·7	19·8	21·0	22·1	23·2						
21	11·3	11·4	11·5	12·7	13·8	15·2	16·5	17·6	18·8	20·0	21·2	22·3	23·5	24·6					
22	11·4	11·4	11·5	12·7	13·9	15·3	16·6	17·8	19·0	20·2	21·4	22·4	23·7	24·8	26·0				
23	11·5	11·5	11·5	12·7	13·9	15·4	16·7	18·0	19·2	20·4	21·6	22·7	23·9	25·0	26·2	27·3			
24	11·6	11·6	11·6	12·8	14·0	15·5	16·8	18·1	19·4	20·6	21·8	23·0	24·2	25·3	26·5	27·6	28·6		
25	11·7	11·7	11·7	12·9	14·2	15·6	17·0	18·3	19·6	20·8	22·1	23·3	24·5	25·6	26·8	27·8	28·8	29·8	
26	11·9	11·9	11·9	13·2	14·5	15·8	17·2	18·6	19·9	21·1	22·4	23·6	24·8	25·9	27·1	28·1	29·0	30·0	30·9
27	12·0	12·0	12·0	13·4	14·7	16·1	17·5	18·8	20·2	21·4	22·7	23·9	25·1	26·2	27·4	28·3	29·3	30·2	31·1
28	12·2	12·2	12·2	13·6	15·0	16·4	17·8	19·1	20·5	21·7	23·0	24·2	25·4	26·5	27·7	28·6	29·6	30·5	31·4
29	12·4	12·4	12·4	13·9	15·3	16·6	18·0	19·4	20·7	22·0	23·2	24·5	25·7	26·8	28·0	29·0	29·9	30·9	31·8
30	12·6	12·6	12·6	14·0	15·5	16·9	18·3	19·7	21·0	22·3	23·5	24·7	26·0	27·2	28·3	29·3	30·2	31·2	32·1
31	12·9	12·9	12·9	14·3	15·7	17·2	18·5	19·9	21·2	22·5	23·8	25·0	26·2	27·4	28·6	29·6	30·6	31·6	32·5
32	13·2	13·2	13·2	14·6	16·0	17·5	18·8	20·2	21·5	22·8	24·1	25·3	26·5	27·7	28·9	30·0	31·0	32·0	32·9
33	13·6	13·6	13·6	14·9	16·3	17·7	19·1	20·5	21·8	23·1	24·4	25·6	26·8	28·0	29·2	30·3	31·3	32·3	33·3
34	14·0	14·0	14·0	15·2	16·6	18·0	19·4	20·8	22·1	23·4	24·7	26·0	27·2	28·4	29·5	30·6	31·6	32·6	33·6
35	14·4	14·4	14·4	15·5	16·9	18·3	19·7	21·1	22·4	23·7	25·0	26·3	27·5	28·7	29·8	30·9	31·9	32·9	33·9
36	14·9	14·9	14·9	15·9	17·2	18·5	20·0	21·4	22·7	24·1	25·4	26·7	27·9	29·1	30·2	31·2	32·3	33·3	34·3
37	15·3	15·3	15·3	16·3	17·5	18·8	20·3	21·7	23·0	24·4	25·7	27·0	28·2	29·4	30·5	31·6	32·6	33·7	34·7
38	15·8	15·8	15·8	16·7	17·8	19·1	20·6	22·0	23·3	24·7	26·0	27·3	28·6	29·8	30·9	32·0	33·0	34·1	35·1
39	16·2	16·2	16·2	17·1	18·1	19·4	20·9	22·3	23·6	25·0	26·3	27·7	29·0	30·2	31·3	32·4	33·4	34·5	35·5
40	16·7	16·7	16·7	17·5	18·4	19·7	21·2	22·6	24·0	25·4	26·7	28·1	29·4	30·6	31·7	32·8	33·9	34·9	35·9
41	17·2	17·2	17·2	17·9	18·8	20·0	21·5	23·0	24·4	25·8	27·1	28·5	29·8	31·0	32·1	33·2	34·3	35·4	36·4
42	17·7	17·7	17·7	18·3	19·2	20·4	21·9	23·4	24·9	26·3	27·6	28·9	30·2	31·4	32·5	33·7	34·8	35·9	36·9
43	18·2	18·2	18·2	18·7	19·5	20·7	22·3	23·8	25·3	26·7	28·0	29·4	30·7	31·9	33·0	34·2	35·3	36·4	37·4
44	18·7	18·7	18·7	19·1	19·8	21·1	22·7	24·2	25·7	27·1	28·5	29·9	31·2	32·4	33·6	34·7	35·8	36·9	37·9
45	19·2	19·2	19·2	19·5	20·1	21·5	23·1	24·6	26·1	27·6	29·0	30·4	31·7	33·0	34·2	35·3	36·3	37·4	38·4
46	19·7	19·7	19·7	19·9	20·5	21·9	23·5	25·0	26·5	28·0	29·5	30·9	32·2	33·5	34·8	35·8	36·8	37·8	38·8

NOTES.—TABLE 68

1. **Span** is to be measured from transverse to transverse or from transverse to "span point" (*see* Sketch following Table 77) of the end connection.
2. **Head** is the vertical distance from the longitudinal to the deck at side, amidships.
3. **Corrections to modulus of longitudinals.**

FOR SPAN: If the span is $\frac{\text{greater}}{\text{less}}$ than 10 feet, modulus of longitudinals to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of $\frac{20 \text{ per cent}}{15 \text{ per cent}}$ per foot of difference; the modulus is not to be less than that required for an 8 feet spacing of transverses.

LONGITUDINALS
nd having a span of 10 feet

TABLE 68

HEAD—FEET																		DEPTH
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	D
← Modulus—Inches[a] →																			Feet
																			16
																			17
																			18
																			19
																			20
																			21
																			22
																			23
																			24
																			25
																			26
																			27
33·2																			28
33·6	34·6																		29
34·1	35·1	36·1																	30
34·5	35·5	36·5	37·5																31
34·9	35·9	36·9	37·9	38·9															32
35·2	36·3	37·2	38·2	39·1	40·0														33
35·6	36·6	37·5	38·4	39·3	40·2	41·1													34
35·9	36·9	37·9	38·8	39·6	40·5	41·4	42·3												35
36·3	37·3	38·3	39·1	40·0	40·8	41·7	42·6	43·4											36
36·7	37·7	38·6	39·5	40·4	41·2	42·1	43·0	43·8	44·6										37
37·1	38·1	39·0	39·9	40·8	41·6	42·5	43·4	44·2	45·1	45·9									38
37·5	38·5	39·4	40·3	41·2	42·1	42·9	43·8	44·6	45·5	46·3	47·1								39
37·9	38·9	39·9	40·8	41·6	42·5	43·3	44·2	45·0	45·9	46·7	47·6	48·4							40
38·4	39·4	40·3	41·2	42·0	42·9	43·7	44·6	45·4	46·3	47·1	48·0	48·8	49·6						41
38·9	39·9	40·8	41·7	42·5	43·4	44·2	45·1	45·9	46·8	47·6	48·5	49·3	50·2	51·0					42
39·3	40·3	41·2	42·1	43·0	43·9	44·8	45·6	46·4	47·3	48·1	49·0	49·8	50·7	51·5	52·3				43
39·8	40·8	41·7	42·6	43·5	44·4	45·3	46·2	47·0	47·9	48·7	49·6	50·4	51·2	51·9	52·7	53·4			44
40·3	41·3	42·2	43·1	44·0	44·9	45·8	46·7	47·6	48·5	49·3	50·2	51·0	51·7	52·4	53·1	53·8	54·5		45
40·8	41·8	42·7	43·6	44·5	45·4	46·3	47·2	48·1	49·0	49·9	50·8	51·6	52·3	52·9	53·6	54·2	54·8	55·5	46

NOTES.—TABLE 68 (*concluded*)

FOR SPACING OF LONGITUDINALS:

If the spacing of longitudinals differs from 30 inches the modulus is to be modified in direct proportion.

4. For minimum thickness of longitudinals *see* Table 77.

5. Particulars of sections and moduli are given in Table 56.

TABLE 69

Span

DEPTH D	FRAME SPACING	NUMBER OF STRINGERS	MINIMUM DEPTH OF FRAMES	HEAD—FEET															
				Not exceeding 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	2
Feet	Inches		Inches	< Modulus—Inches³															
16	25	1	6	8·3	9·3	10·6	11·9	13·2	14·6	15·9									
17	25¼	1	6	8·4	9·4	10·7	12·0	13·4	14·7	16·0	17·4								
18	25½	1	6	8·5	9·5	10·8	12·1	13·5	14·9	16·2	17·6	18·9							
19	25¾	1	6	8·6	9·5	10·9	12·2	13·6	15·0	16·3	17·7	19·1	20·4	21·8					
20	26	1	6	8·7	9·6	11·0	12·3	13·7	15·1	16·5	17·9	19·2	20·6	22·0	23·4	24·7			
21	26¼	1	6	8·7	9·7	11·1	12·5	13·9	15·3	16·7	18·1	19·4	20·8	22·2	23·6	25·0	26·4		
22	26½	1	7	8·8	9·8	11·2	12·6	14·0	15·4	16·8	18·2	19·6	21·0	22·4	23·8	25·2	26·6	28·0	
23	26¾	1	7	8·9	9·9	11·3	12·7	14·2	15·6	17·0	18·4	19·8	21·2	22·7	24·1	25·5	26·9	28·3	29
24	27	1	7	9·0	10·0	11·4	12·9	14·3	15·7	17·2	18·6	20·0	21·4	22·9	24·3	25·7	27·1	28·6	30
25	27¼	2	7	9·0	10·1	11·5	13·0	14·4	15·9	17·3	18·8	20·2	21·6	23·1	24·5	26·0	27·4	28·9	30
26	27½	2	7	9·1	10·2	11·6	13·1	14·5	16·0	17·5	18·9	20·4	21·8	23·3	24·7	26·2	27·6	29·1	30
27	27¾	2	7	9·2	10·3	11·7	13·2	14·7	16·2	17·6	19·1	20·6	22·0	23·5	25·0	26·4	27·9	29·4	30
28	28	2	8	9·3	10·4	11·8	13·3	14·8	16·3	17·8	19·3	20·7	22·2	23·7	25·2	26·7	28·2	29·6	31
29	28¼	2	8	9·4	10·5	12·0	13·5	15·0	16·5	18·0	19·4	20·9	22·4	23·9	25·4	26·9	28·4	29·9	31
30	28½	2	8	9·5	10·2	10·8	11·7	13·1	14·4	15·7	17·0	18·3	19·6	20·9	22·2	23·5	24·8	26·1	27
31	28¾	2	8	9·6	10·3	10·9	11·8	13·2	14·5	15·8	17·1	18·4	19·8	21·1	22·4	23·7	25·0	26·3	27
32	29	2	9	9·7	10·4	11·0	11·9	13·3	14·6	15·9	17·2	18·6	19·9	21·2	22·5	23·9	25·2	26·6	27
33	29¼	2	9	9·7	10·4	11·1	12·0	13·4	14·7	16·1	17·4	18·7	20·1	21·4	22·7	24·1	25·4	26·8	28
34	29½	2	9	9·8	10·5	11·2	12·1	13·5	14·9	16·2	17·5	18·9	20·2	21·6	23·0	24·3	25·6	27·0	28
35	29¾	2	9	9·9	10·6	11·3	12·3	13·6	15·0	16·4	17·7	19·1	20·4	21·8	23·2	24·5	25·9	27·3	28
36	30	3	9	10·0	10·7	11·4	12·1	13·0	14·3	15·6	16·9	18·2	19·5	20·8	22·1	23·4	24·7	26·0	27
37	30¼	3	9	10·1	10·8	11·5	12·2	13·1	14·4	15·7	17·0	18·3	19·6	21·0	22·3	23·6	24·9	26·2	27
38	30½	3	10	10·2	10·9	11·6	12·4	13·2	14·5	15·8	17·2	18·5	19·8	21·1	22·5	23·8	25·1	26·4	27
39	30¾	3	10	10·3	11·0	11·7	12·5	13·3	14·6	16·0	17·3	18·6	20·0	21·3	22·6	24·0	25·3	26·6	28
40	31	3	10	10·3	11·1	11·8	12·6	13·4	14·8	16·1	17·4	18·8	20·1	21·5	22·8	24·2	25·5	26·8	28
41	31¼	3	10	10·4	11·2	11·9	12·7	13·5	14·9	16·2	17·6	18·9	20·3	21·6	23·0	24·3	25·7	27·0	28
42	31½	3	10	10·5	11·3	12·0	12·8	13·6	15·0	16·4	17·7	19·1	20·5	21·8	23·2	24·5	25·9	27·3	28
43	31¾	3	10	10·6	11·3	12·1	12·9	13·7	15·1	16·5	17·9	19·2	20·6	22·0	23·4	24·7	26·1	27·5	28
44	32	3	11	10·7	11·4	12·2	13·0	13·8	15·2	16·6	18·0	19·4	20·7	22·2	23·5	24·9	26·3	27·7	29
45	32¼	3	11	10·7	11·5	12·3	13·1	13·9	15·3	16·7	18·1	19·5	20·9	22·3	23·7	25·1	26·5	27·9	29
46	32⅓	3	11	10·8	11·6	12·4	13·2	14·1	15·5	16·9	18·3	19·7	21·1	22·5	23·9	25·3	26·7	28·1	29

WEB AT EVERY TRANSVERSE

NOTES.—TABLE 69

1. **Span** is to be measured from stringer to stringer or from stringer to "span point" (*see* Sketch, following Table 77) of top or bottom b
2. **Head** is the vertical distance from the mid-point of the span to the deck at side, at mid-length of tank.
3. **Corrections to modulus of frames.**

FOR SPAN: If the span is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than 10 feet, modulus of frames to be $\begin{matrix}\text{increased by 25 per cent}\\\text{reduced by 15 per cent}\end{matrix}$ per foot of difference.

FOR SPACING OF FRAMES: If the spacing differs from that given in the Table, modulus of frames to be modified in direct proportion.

TABLE 69

HEAD—FEET																			DEPTH
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	D
← Modulus—Inches³ →																			Feet
																			16
																			17
																			18
																			19
																			20
																			21
																			22
																			23
31·4																			24
31·7	33·2																		25
32·0	33·5	34·9																	26
32·3	33·8	35·2	36·7																27
32·6	34·1	35·6	37·0	38·5															28
32·9	34·4	35·9	37·4	38·9	40·4														29
28·7	30·0	31·3	32·6	33·9	35·2	36·5													30
29·0	30·3	31·6	32·9	34·2	35·5	36·9	38·2												31
29·2	30·5	31·8	33·2	34·5	35·8	37·1	38·5	39·8											32
29·4	30·8	32·1	33·5	34·8	36·1	37·5	38·8	40·1	41·5										33
29·7	31·0	32·4	33·7	35·1	36·5	37·8	39·2	40·5	41·9	43·2									34
30·0	31·3	32·7	34·0	35·4	36·8	38·2	39·5	40·9	42·2	43·6	45·0								35
28·6	29·9	31·2	32·5	33·8	35·1	36·4	37·7	39·0	40·3	41·6	42·9	44·2							36
28·8	30·1	31·4	32·7	34·0	35·4	36·7	38·0	39·3	40·6	41·9	43·2	44·5	45·8						37
29·0	30·4	31·7	33·0	34·3	35·7	37·0	38·3	39·6	40·9	42·2	43·6	44·9	46·2	47·5					38
29·3	30·6	32·0	33·3	34·6	36·0	37·3	38·6	39·9	41·3	42·6	43·9	45·3	46·6	47·9	49·2				39
29·5	30·9	32·2	33·5	34·9	36·2	37·6	38·9	40·2	41·6	42·9	44·3	45·6	47·0	48·3	49·6	51·0			40
29·8	31·1	32·5	33·8	35·2	36·5	37·9	39·2	40·6	41·9	43·3	44·6	46·0	47·3	48·7	50·0	51·4	52·8		41
30·0	31·4	32·7	34·1	35·5	36·8	38·2	39·5	40·9	42·3	43·6	45·0	46·4	47·7	49·1	50·4	51·8	53·2	54·5	42
30·2	31·6	33·0	34·4	35·7	37·1	38·5	39·9	41·3	42·6	44·0	45·4	46·7	48·1	49·5	50·8	52·2	53·6	55·0	43
30·5	31·9	33·2	34·6	36·0	37·4	38·8	40·2	41·6	42·9	44·3	45·7	47·1	48·5	49·9	51·2	52·6	54·0	55·4	44
30·7	32·1	33·5	34·9	36·3	37·7	39·1	40·5	41·9	43·2	44·6	46·0	47·4	48·8	50·2	51·6	53·0	54·4	55·8	45
30·9	32·3	33·8	35·2	36·6	38·0	39·4	40·8	42·2	43·6	45·0	46·4	47·8	49·2	50·6	52·0	53·4	54·8	56·2	46

NOTES.—TABLE 69 (*concluded*)

4. When D is 30 feet or more the modulus given in the Table is that required if side transverses are fitted in conjunction with the bottom and deck transverses; if these are not fitted the modulus given in the Table is to be increased by 15 per cent. *See also* D 4105.

5. For values of D between 29 and 30 feet and between 35 and 36 feet the Table modulus is to be extrapolated from the group appropriate to the arrangement of stringers and webs.

6. For minimum thickness of frames *see* Table 77.

7. Particulars of sections and moduli are given in Table 56.

TABLE 70

SHELL AND STRENGTH

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	SPACING OF TRANSVERSE SIDE FRAMING	SPACING OF LONGITUDINAL FRAMING	KEEL		THICKNESS OF SHELL PLATING FOR ·5L AMIDSHIPS			
								BOTTOM		SIDE	
						WIDTH	THICKNESS	WITH LONGITUDINAL FRAMING	MINIMUM FOR TABLE SPACING OF LONGITUDINAL FRAMES	WITH TRANSVERSE FRAMING	WITH LONGITUDINAL FRAMING
1	2	3	4	5	6	7	8	9	10	11	12
Feet	Feet	Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
240	40	19·0	14·4	24½	27	43	·65	·45	·45	·42	·41
250	41	19·75	15·0	24¾	27¼	43	·66	·46	·46	·43	·42
260	42	20·5	15·6	25	27½	44	·67	·47	·47	·44	·43
270	43	21·25	16·2	25¼	27¾	44	·69	·48	·48	·45	·44
280	44	22·0	16·8	25½	28	45	·70	·50	·50	·46	·45
290	45	22·75	17·4	25¾	28¼	45	·71	·51	·51	·47	·46
300	46	23·5	18·0	26	28½	46	·73	·52	·52	·48	·47
310	47	24·25	18·6	26¼	28¾	46	·75	·53	·53	·49	·48
320	48	25·0	19·2	26½	29	47	·76	·54	·54	·50	·49
330	49	25·75	19·8	26¾	29¼	47	·78	·55	·55	·51	·50
340	50	26·5	20·4	27	29½	48	·79	·56	·56	·52	·51
350	51	27·25	21·0	27¼	29¾	48	·80	·58	·57	·53	·52
360	52	28·0	21·6	27½	30	49	·82	·60	·58	·54	·53
370	53	28·75	22·2	27¾	30¼	49	·84	·62	·59	·55	·54
380	54	29·5	22·8	28	30½	50	·86	·63	·60	·56	·55
390	55	30·25	23·4	28¼	30¾	50	·88	·64	·61	·57	·56
400	56	31·0	24·0	28½	31	51	·89	·66	·62	·58	·57
410	57	31·75	24·6	28¾	31¼	51	·91	·68	·63	·59	·58
420	58	32·5	25·2	29	31½	52	·93	·69	·64	·60	·59
430	59	33·25	25·8	29¼	31¾	52	·94	·70	·65	·61	·60
440	60	34·0	26·4	29½	32	53	·96	·72	·66	·62	·61
450	61	34·75	27·0	29¾	32¼	53	·97	·74	·68	·63	·62
460	62	35·5	27·6	30	32½	54	·98	·76	·69	·64	·63
470	63	36·25	28·2	30¼	32¾	54	1·00	·78	·71	·65	·64
480	64	37·0	28·8	30½	33	55	1·02	·80	·73	·66	·65
490	65	37·75	29·4	30¾	33¼	55	1·03	·82	·75	·67	·66
500	66	38·5	30·0	31	33½	56	1·04	·84	·77	·69	·67
510	67	39·25	30·6	31¼	33¾	57	1·06	·86	·79	·70	·69
520	68	40·0	31·2	31½	34	57	1·07	·88	·81	·71	·70
530	69	40·75	31·8	31¾	34	58	1·09	·90	·83	·73	·71
540	70	41·5	32·1	32	34	59	1·11	·92	·85	·75	·72
550	72	42·25	32·4	32¼	34	59	1·12	·94	·87	·76	·73
560	74	43·0	32·7	32½	34	60	1·13	·97	·89	·77	·74
570	76	43·75	33·0	32¾	34	60	1·14	1·00	·91	·79	·76
580	78	44·5	33·3	33	34	61	1·15	1·03	·93	·80	·77
590	80	45·25	33·6	33¼	34	61	1·16	1·06	·95	·82	·78
600	82	46·0	33·9	33½	34	62	1·17	1·08	·97	·83	·80
610	83	46·75	34·2	33¾	34	63	1·18	1·11	·99	·84	·81
620	84	47·5	34·5	34	34	63	1·20	1·14	1·01	·85	·82

For notes see page 214

DECK PLATING

THICKNESS OF BOTTOM AND SIDE PLATING FOR ·05L FROM ENDS	WIDTH OF SHEER-STRAKE AND STRINGER PLATE FOR ·5L AMIDSHIPS	THICKNESS OF SHEER-STRAKE FOR ·5L AMIDSHIPS	WIDTH OF FLANGES OF STRINGER ANGLE FOR ·5L AMIDSHIPS	STRENGTH DECK FOR ·5L AMIDSHIPS					THICKNESS OF STRENGTH DECK FOR ·05L FROM ENDS	BASIC AREA OF LONGITUDINALS PER FOOT OF BREADTH B		LENGTH L
				SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:—* B *and* B_b	D *and* D_b	d *and* d_b	MINIMUM THICKNESS		BOTTOM	DECK	
13	14	15	16	17	18	19	20	21	22	23	24	25
Inches	Inches	Inches	Inches	Sq. inches	Per cent	Per cent	Per cent	Inches	Inches	Sq. inches	Sq. inches	Feet
·37	52	·58	6	48	*3·7*	*18·0*	*6·3*	·34	·29	1·80	·90	240
·37	52	·59	6	54	*3·6*	*17·0*	*6·2*	·34	·29	1·85	·90	250
·38	53	·61	6	60	*3·6*	*16·0*	*6·2*	·34	·29	1·90	·90	260
·38	53	·62	6	66	*3·5*	*15·0*	*6·1*	·35	·29	1·95	·95	270
·39	54	·64	6	72	*3·4*	*14·0*	*6·1*	·35	·30	2·00	·95	280
·39	54	·65	6	79	*3·3*	*13·0*	*6·0*	·35	·30	2·05	1·00	290
·40	55	·67	6	86	*3·3*	*12·0*	*6·0*	·36	·30	2·10	1·00	300
·40	55	·68	6	93	*3·2*	*11·0*	*5·9*	·36	·30	2·10	1·00	310
·41	56	·70	6	101	*3·2*	*10·0*	*5·9*	·37	·31	2·10	1·05	320
·41	56	·71	6	110	*3·1*	*9·5*	*5·8*	·37	·31	2·15	1·05	330
·42	57	·73	6	119	*3·0*	*9·0*	*5·8*	·38	·31	2·20	1·10	340
·42	57	·74	6	129	*2·9*	*8·5*	*5·7*	·39	·31	2·25	1·10	350
·43	58	·76	6	139	*2·9*	*8·0*	*5·7*	·40	·32	2·30	1·15	360
·43	58	·77	6	149	*2·8*	*7·6*	*5·6*	·41	·32	2·35	1·15	370
·44	59	·79	6	159	*2·8*	*7·4*	*5·6*	·42	·32	2·40	1·20	380
·44	59	·80	6	168	*2·7*	*7·2*	*5·5*	·43	·32	2·45	1·20	390
·45	60	·82	6	178	*2·6*	*7·0*	*5·5*	·44	·33	2·50	1·20	400
·45	60	·83	6	189	*2·6*	*6·8*	*5·4*	·45	·33	2·55	1·25	410
·46	61	·85	6	200	*2·5*	*6·6*	*5·4*	·46	·33	2·60	1·25	420
·46	61	·86	6	211	*2·4*	*6·4*	*5·3*	·47	·33	2·65	1·30	430
·47	62	·88	6	222	*2·4*	*6·2*	*5·3*	·48	·34	2·70	1·30	440
·47	62	·90	7	234	*2·3*	*6·0*	*5·2*	·49	·34	2·75	1·30	450
·48	63	·92	7	247	*2·2*	*5·9*	*5·1*	·50	·34	2·80	1·35	460
·48	63	·93	7	261	*2·2*	*5·8*	*5·0*	·52	·34	2·85	1·35	470
·49	64	·95	7	275	*2·1*	*5·7*	*4·9*	·54	·34	2·90	1·35	480
·49	64	·96	7	290	*2·1*	*5·6*	*4·8*	·55	·34	3·00	1·40	490
·50	65	·98	7	306	*2·0*	*5·5*	*4·7*	·56	·35	3·10	1·40	500
·50	65	·99	7	322	*1·9*	*5·4*	*4·6*	·58	·35	3·15	1·40	510
·51	66	1·01	7	338	*1·9*	*5·3*	*4·5*	·60	·35	3·20	1·45	520
·51	66	1·02	7	354	*1·8*	*5·2*	*4·4*	·61	·35	3·25	1·45	530
·52	67	1·04	7	370	*1·8*	*5·1*	*4·3*	·62	·35	3·30	1·45	540
·52	67	1·06	7	393	*1·7*	*5·0*	*4·2*	·64	·35	3·35	1·50	550
·53	68	1·08	8	417	*1·7*	*4·8*	*4·1*	·66	·36	3·40	1·50	560
·53	68	1·11	8	441	*1·7*	*4·6*	*3·9*	·67	·36	3·45	1·50	570
·54	69	1·14	8	465	*1·6*	*4·5*	*3·7*	·68	·36	3·50	1·55	580
·55	69	1·16	8	490	*1·6*	*4·4*	*3·6*	·69	·36	3·55	1·55	590
·56	70	1·18	8	514	*1·6*	*4·2*	*3·5*	·70	·36	3·60	1·60	600
·56	71	1·21	8	534	*1·6*	*4·1*	*3·4*	·71	·36	3·65	1·60	610
·57	72	1·24	8	554	*1·5*	*4·0*	*3·4*	·72	·37	3·70	1·60	620

For notes see page 214

TABLE 70
(CONCLUDED)

SHELL AND STRENGTH DECK PLATING

NOTES.—TABLE 70

1. **Keel.**—The width and thickness of the keel plate (cols. 7 & 8) are to be maintained throughout; the thickness is not to be reduced if the width is greater than required.

2. **Bottom plating** (from keel to upper turn of bilge).

(*a*) The Table thickness (col. 9) is to be corrected, if necessary, as follows :—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 0·7 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, the thickness, after correction for depth where necessary, is to be $\frac{\text{increased}}{\text{reduced}}$ by 1·5 per cent per foot of difference.

(*b*) If the seams are riveted the thickness corrected as above may be reduced by 6 per cent.

(*c*) If the area of the bottom longitudinals per foot of breadth B is $\frac{\text{greater}}{\text{less}}$ than the basic area in col. 23 (and *see* note 9) the thickness is to be $\frac{\text{reduced}}{\text{increased}}$ at the rate of ·01 inch for every ·15 square inch of difference in area per foot of bottom longitudinals.

(*d*) If the spacing of longitudinals differs from that given in col. 6 the corrected thickness of plating is to be modified at the rate of ·01 inch for every inch of difference.

(*e*) The minimum thickness amidships (col. 10) is to be corrected for spacing of longitudinals only.

3. **Side plating** (from upper turn of bilge to lower edge of sheerstrake).

The Table thickness (cols. 11 or 12) is to be corrected, if necessary, as required for bottom plating by note 2(*a*).

If the spacing of transverse or longitudinal framing differs from that given in col. 5 or 6, the corrected thickness is to be modified at the rate of ·01 inch per inch of difference.

Notes 2(*b*) and (*c*) do not apply to side plating.

4. **Shell plating at ends.**—The thickness of side and bottom plating is to taper gradually from the midship thickness (cols. 9 to 12) to the end thickness (col. 13), except as qualified by D 4706.

The thickness in col. 13 is not subject to corrections for depth and draught.

5. **Sheerstrake.**—(*a*) The Table thickness (col. 15) is to be corrected if necessary, as follows :—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 4 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, the thickness, after correction for depth where necessary, is to be $\frac{\text{increased}}{\text{reduced}}$ by 4 per cent per foot of difference.

(*b*) The thickness of the sheerstrake is not to be corrected for frame spacing. At the ends the thickness is to be the same as that of the side plating.

6. **Stringer angle.**—The width of flanges of the stringer angle is given in col. 16. The thickness is to be that of the stringer plate or sheerstrake whichever is less. *See also* D 4403.

7. **Stringer plate.**—The width for ·5L amidships is given in col. 14, and for ·05L at ends is not to be less than 60 per cent of that width.

The thickness is not to be less than 85 per cent of the sheerstrake, corrected as required by note 5, and not less than ·04 greater than that given in col. 21.

8. **Strength deck plating.**—(*a*) The area given in col. 17 is the sectional area of deck plating including stringer plate and stringer angle on one side of the ship abreast openings. If riveted overlapped seams are fitted they may be included in determining the required deck thickness.

(*b*) The Table area is to be corrected, if necessary as follows :—

FOR BREADTH.

If B is $\frac{\text{greater}}{\text{less}}$ than B_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (col. 18) per foot of difference.

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, area, after correction for breadth where necessary, to be $\frac{\text{reduced}}{\text{increased}}$ by the given percentage (col. 19) per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, area, after correction for depth and breadth when necessary, to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (col. 20) per foot of difference.

(*c*) If the area of deck longitudinals abreast openings per foot of breadth B is $\frac{\text{greater}}{\text{less}}$ than the basic area in col. 24 (and *see* note 9) the thickness of the stringer and deck plating is to be $\frac{\text{reduced}}{\text{increased}}$ at the rate of ·01 inch for every ·15 square inch of difference in area.

If after the above correction the thickness of the stringer plate requires to be increased to comply with note 7 the total area of deck plating and stringer is to be maintained.

(*d*) If the spacing of longitudinals differs from that given in col. 6 the minimum thickness of deck plating for ·5L amidships (col. 21) is to be modified at the rate of ·01 inch for every 2 inches of difference.

(*e*) The thickness of deck plating is to taper gradually from the midship thickness to the end thickness (col. 22), except as qualified by D 4504 and D 4505.

9. **Area of longitudinals.**—The basic area of bottom and deck longitudinals (cols. 23 and 24) is the sectional area of longitudinals per foot of breadth B for a 10 ft. span of longitudinals. The total area of bottom longitudinals is to include those at the bilge and longitudinal bulkheads up to ·1D from the base line. The total area of deck longitudinals is to include those at ship's side and at longitudinal bulkheads down to ·1D from the deck line at side.

If the span of longitudinals is $\frac{\text{greater}}{\text{less}}$ than 10 feet the basic area is to be $\frac{\text{increased by 10 per cent}}{\text{reduced by 5 per cent}}$ for every foot of difference. The reduction should not exceed 10 per cent.

BULKHEAD PLATING

LENGTH L	SPACING OF HORIZONTAL OR VERTICAL STIFFENERS	TOP STRAKE OF LONGITUDINAL BULKHEAD	BOTTOM STRAKE OF LONGITUDINAL BULKHEAD	DEPTH FEET							
				Not exceeding 18	22	26	30	34	38	42	46
Feet	Inches	Inches	Inches	<—— Inches ——>							
240	27	·34	·38	·34							
260	27	·34	·38	·34							
280	27	·34	·39	·34							
300	28	·36	·40	·36	·38						
320	28	·38	·41	·38	·38						
340	29	·38	·42	·38	·39						
360	29	·39	·44	·39	·40	·42					
380	30	·42	·46	·40	·41	·43					
400	30	·43	·48	·41	·42	·43	·45				
420	30	·43	·50	·41	·42	·43	·45				
440	30	·44	·51	·42	·42	·43	·45	·47			
460	30	·45	·52	·42	·42	·44	·46	·48	·50		
480	30	·46	·53	·42	·42	·44	·46	·48	·50		
500	30	·47	·54	·42	·42	·44	·46	·48	·50	·52	
520	30	·48	·55	·42	·42	·44	·46	·48	·50	·52	
540	30	·49	·56	·42	·42	·44	·46	·48	·50	·52	·54
560	30	·50	·57	·43	·43	·44	·46	·48	·50	·52	·54
580	30	·51	·58	·43	·43	·44	·46	·48	·50	·52	·54
600	30	·52	·58	·44	·44	·44	·46	·48	·50	·52	·54
620	30	·53	·59	·44	·44	·44	·46	·48	·50	·52	·54

NOTES.—TABLE 71

1. **Depth** is to be measured from the highest point of the tank, excluding the hatchway, to the lower edge of the plate, whether the plating is arranged in vertical or horizontal strakes.

2. **Correction for spacing of stiffeners.**—If the spacing of stiffeners differs from the Table spacing, the thickness of the plating, including top and bottom strakes, is to be modified at the rate of 2 per cent for every inch of difference.

3. The width of the top and bottom strakes is not to be less than ·15 D.

TABLE 72

BULKHEAD STIFFENERS

Spaced 30 inches apart and having a span of 10 feet

HEAD	MODULUS OF STIFFENER	HEAD	MODULUS OF STIFFENER
Feet	Inches³	Feet	Inches³
4	8·5	23	29·8
5	9·2	24	31·1
6	10·0	25	32·3
7	10·7	26	33·6
8	11·4	27	34·8
9	12·2	28	36·0
10	13·0	29	37·1
11	14·3	30	38·2
12	15·6	31	39·2
13	16·9	32	40·1
14	18·2	33	41·0
15	19·5	34	41·9
16	20·8	35	42·7
17	22·1	36	43·6
18	23·4	37	44·4
19	24·7	38	45·3
20	26·0	39	46·2
21	27·3	40	47·1
22	28·6		

NOTES.—TABLE 72

1. **Span** is to be measured from web to web or girder to girder or from web or girder to the "span point" (*see* Sketch, following Table 77) on the end connection.

2. **Head** is the vertical distance from the centre of the span to the highest point of the tank, excluding the hatchway.

3. **Corrections to modulus of stiffeners.**

FOR SPAN :

If the span is $\frac{\text{greater}}{\text{less}}$ than 10 feet, modulus to be $\frac{\text{increased}}{\text{decreased}}$ at the rate of $\frac{25 \text{ per cent}}{18 \text{ per cent}}$ per foot of difference.

FOR SPACING OF STIFFENERS :

If the spacing of stiffeners differs from 30 inches the modulus is to be modified in direct proportion.

4. The modulus of horizontal stiffeners on longitudinal bulkheads is not to be less than 90 per cent of the modulus of the uppermost side longitudinal.

5. The modulus of longitudinal bulkhead vertical stiffeners may be reduced, after correction as required by note 3, by 10 per cent if vertical webs are fitted.

6. For minimum thickness of stiffeners *see* Table 77.

7. Particulars of sections and moduli are given in Table 56.

TABLE 73

FLOORS AT FORE END

DEPTH D	FLOOR PLATE		FACE AREA	DEPTH D	FLOOR PLATE		FACE AREA
	DEPTH	THICKNESS			DEPTH	THICKNESS	
Feet	Inches	Inches	Sq. inches	Feet	Inches	Inches	Sq. inches
16	20	·31	0·6	32	40	·42	2·2
18	22	·33	0·8	34	43	·43	2·4
20	25	·34	1·0	36	46	·44	2·6
22	28	·36	1·2	38	48	·45	2·8
24	30	·37	1·4	40	50	·47	3·0
26	33	·39	1·6	42	52	·48	3·2
28	36	·40	1·8	44	54	·49	3·4
30	38	·41	2·0	46	56	·51	3·6

NOTES.—TABLE 73

1. **Depth** given in the Table is the depth of the floor plate at the centre line.

2. **Correction for spacing.** If the spacing of floors differs from 27 inches or the spacing required for transverse frames in Table 12, whichever is less, the thickness is to be modified at the rate of ·01 inch for every two inches of difference.

TABLE 74

BOTTOM PLATING FORWARD

LENGTH L	THICKNESS (with welded seams, longitudinals & floors.)		REDUCTION IN THICKNESS IF SEAMS, LONGITUDINALS & FLOORS RIVETED	
	At longl. framing	At trans. framing		Inches
Feet	Inches	Inches		
250	·50	·50	LENGTH NOT EXCEEDING 500 feet.	0·04
300	·55	·54		
350	·61	·59		
400	·68	·65		
450	·75	·71		
500	·81	·76	LENGTH ABOVE 500 feet & NOT EXCEEDING 550 feet.	0·02
550	·87	·82		
600 AND ABOVE.	·94	·88	LENGTH EXCEEDING 550 feet.	nil

NOTES.—TABLE 74

1. The thickness of bottom plating forward is not to be less at any point than would be required for the normal taper from midship to end thickness by Table 70.

See also D 4706.

2. **Correction for spacing.** If the spacing of floors differs from 27 inches or that given in col. 5 of Table 70, whichever is less, or the spacing of longitudinals differs from that given in col. 6, Table 70, the thickness of the plating is to be modified at the rate of ·01 inch per inch of difference.

TABLE 75

WEB FRAMES AND SIDE STRINGERS AT FORE END

Web frames spaced 9 ft. apart supporting one side stringer

DEPTH D	h - FEET									
	8	10	12	14	16	18	20	22	24	26
	FACE AREA IN SQUARE INCHES									
	1·5	2	3	4	5	6	7	8	9	10
Feet	DEPTH AND THICKNESS OF WEB PLATE IN INCHES									
16	12×·36	14×·36	14×·36	15×·36	15×·36	16×·38				
18	13×·36	14×·36	15×·36	16×·36	17×·36	17×·38	18×·38			
20	13×·36	15×·36	16×·36	17×·36	18×·38	19×·38	19×·38	20×·40		
22	14×·36	16×·36	17×·36	17×·38	19×·38	20×·38	20×·40	21×·40	22×·40	
24	14×·36	16×·38	18×·38	18×·38	20×·38	21×·40	22×·40	23×·40	23×·42	24×·42
26	14×·38	17×·38	19×·38	19×·38	21×·38	22×·40	23×·40	24×·42	25×·42	26×·42
28	15×·38	18×·38	19×·38	20×·38	22×·40	23×·40	24×·42	25×·42	26×·42	27×·44
30	15×·38	18×·38	20×·38	21×·38	23×·40	24×·40	25×·42	27×·42	28×·42	29×·44
32	16×·38	19×·38	20×·38	22×·40	23×·40	25×·42	26×·42	28×·42	29×·44	30×·44
34	16×·38	19×·40	21×·40	23×·40	24×·40	26×·42	27×·42	29×·44	30×·44	31×·46
36	17×·38	20×·40	22×·40	24×·40	25×·42	27×·42	29×·44	30×·44	31×·44	33×·46
38		20×·40	23×·40	24×·40	26×·42	28×·42	30×·44	31×·44	33×·46	34×·46
40		21×·40	23×·40	25×·42	27×·42	29×·44	31×·44	32×·46	34×·46	35×·48
42		21×·40	24×·40	25×·42	27×·44	30×·44	32×·46	33×·46	35×·48	37×·48
44			24×·42	26×·42	28×·44	30×·44	32×·46	34×·46	36×·48	38×·48
46				27×·44	29×·44	31×·46	33×·46	35×·48	37×·48	39×·48

NOTES.—TABLE 75

1. **Depth** of web frames and stringers given in the Table is the depth of the web plate.

Thickness of plates of web frames or stringers is to be the thickness indicated in the Table for the depth of web corrected as below at the appropriate depth D.

2. (*a*)—h in deep tanks is to be measured at the mid-length of the tank from the top of floors to the tank top at side.

In tanks of unusual depth, h may be measured to a suitable side stringer (*see* D 4710 to D 4712) provided the strength of this stringer, and of the supporting webs, is adequately increased.

(*b*) h above the deep tank is to be measured at the mid-length of the hold from the tank top to the lowest deck at side.

3. **Web frames in deep tanks.**—The following corrections are to be made if necessary to the Table depth :

FOR SPACING OF WEB FRAMES.

If the spacing of web frames differs from 9 feet, the depth of web is to be modified at the rate of 7 per cent for every foot of difference.

FOR NUMBER OF STRINGERS.

If two stringers are supported, the depth, after correction for spacing if necessary, is to be increased by 12½ per cent ; if three stringers are supported, the depth is to be increased by 20 per cent.

4. **Side stringers in deep tanks.**—The following corrections are to be made if necessary to the Table depth :

FOR SPACING OF WEB FRAMES.

If the spacing of web frames differs from 9 feet, the depth of stringers is to be modified at the rate of 15 per cent per foot of difference.

FOR NUMBER OF STRINGERS.

The Table depth, after correction for spacing if necessary, may be reduced as follows :—

If one stringer is fitted, 15 per cent
„ two stringers are „ 30 per cent
„ three „ „ „ 40 per cent

The edge of stringer plates is to be stiffened by a 3½ inch flange, or equivalent.

5. **Web frames in the hold above deep tanks.**—The depth of web frames in the hold is to be 80 per cent of the depth obtained from the Table after the following corrections have been made :

FOR SPACING OF WEB FRAMES.

Depth to be modified if necessary as required by Note 3.

FOR NUMBER OF STRINGERS, OR FOR 'TWEEN DECKS.

If more than one stringer is supported, the depth, after correction for spacing if necessary, is to be increased by 12½ per cent ; if there is a 'tween deck (excluding forecastle) above the hold the depth is to be increased by 20 per cent.

The face area may be 80 per cent of the Table area.

6. **Side stringers in hold above deep tanks.**—The depth of stringers is to be 75 per cent of the corrected depth of web frames carrying one stringer. The edge of stringer plates is to be flanged or otherwise suitably stiffened.

A

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATING THICKNESS	LEG LENGTH		
	Type 1	Type 2	Type 3
Inches	Inches	Inches	Inches
·20	·22	·18	·18
·30	·26	·20	·18
·40	·30	·24	·18
·50	·34	·28	·22
·60	·38	·32	·26

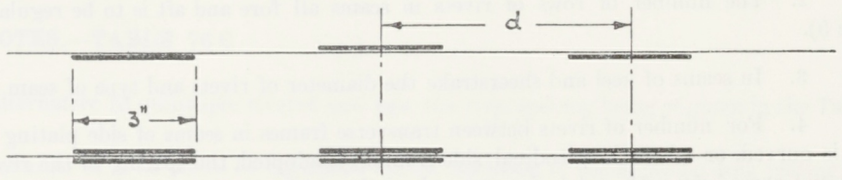
NOTES.—TABLE 76 A

1. **Size of fillet** is the minimum length of leg. The throat thickness of the weld is to be 70 per cent of the leg length.
2. **Leg length** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of the fillet will be specially considered.
3. Leg lengths for intermediate thicknesses to be obtained by direct interpolation.
4. **Minimum leg length** of fillet weld to be ·18 inch.

INTERMITTENT FILLET WELDS

STAGGERED INTERMITTENT (S)
(Type 1)
(To be doubled at ends—*See* D 3114)

CHAIN INTERMITTENT (C)
(Type 1)



SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc. WITH DOUBLE FILLET WELDS.
Type as per Table 76 H
Welding to be carried round the ends of all lugs
See also D 4913

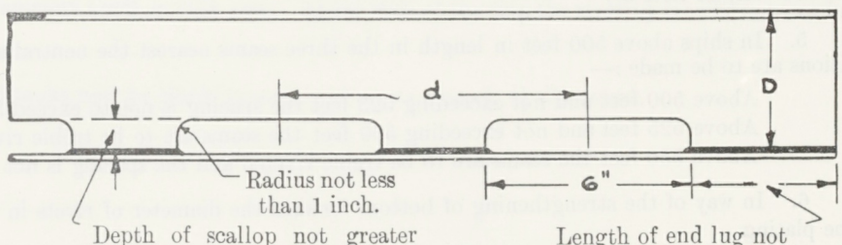


TABLE 76B

WELDING AND RIVETING

B

RIVETING OF END LAPS AND SEAMS OF SHELL PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS			
	Above	Not exceeding	Diameter of rivets	Type	Breadth		Spacing of rivets, centre to centre	Type	Breadth	Spacing of rivets, centre to centre	
					End lap	Butt strap					
	Inches	Inches	Inches		Inches	Inches	Inches		Inches	Inches	
Sheerstrake for ·5L amidships		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	*See* note 3			
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$				
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$				
	·72	·84	1	Quadruple	14	25	4				
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$				
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5				
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$				
Bottom plating from keel to upper turn of bilge for ·5L amidships		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$	
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{3}$	
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$	
	·72	·94	1	Quadruple	14	25	4	Double	6	4	
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$	$4\frac{1}{2}$	
Sheerstrake at ends		·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$	^ |
Side shell plating from upper turn of bilge to sheerstrake.	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$	|
Bottom plating from keel to upper turn of bilge at ends.	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$	|
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$	| *See* Notes 2, 4 & 5
	·72	·94	1	Quadruple	14	25	4	Double	6	4	v
Keel.		·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	*See* note 3			
	·72	·84	1	Quadruple	14	25	4				
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$				
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5				
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$				

NOTES.—TABLE 76 B

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps, the rivet spacing being as given in the Table.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships (except as covered by note 5).

3. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating.

4. For number of rivets between transverse frames in seams of side plating *see* Table 76 D. Where the form of the ship, forward and aft, is curved, or where longitudinal side framing is adopted, the spacing of the rivets is not to exceed $3\frac{1}{2}$ diameters where the thickness of plating does not exceed ·50 inch and 4 diameters where the thickness exceeds ·50 inch. Clear of cargo tanks the spacing of rivets in seams of sheerstrake, side and bottom plating is not to exceed $4\frac{1}{2}$ diameters and in end laps the spacing is not to exceed 4 diameters. (For special requirements for ships above 500 feet, *see* note 5.)

5. In ships above 500 feet in length in the three seams nearest the neutral axis and for three-quarters of the length amidships the following additions are to be made :—

Above 500 feet and not exceeding 525 feet the spacing is not to exceed $3\frac{1}{2}$ diameters.
Above 525 feet and not exceeding 550 feet the seams are to be treble riveted and the spacing is not to exceed 4 diameters.
Above 550 feet the seams are to be treble riveted and the spacing is not to exceed $3\frac{1}{2}$ diameters.

6. In way of the strengthening of bottom forward the diameter of rivets in butts and seams is to be appropriate to the increased thickness of the plating.

7. In way of ice strengthening the diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by Table 52 A for the increased thickness of plating.

WELDING AND RIVETING

C

RIVETING OF END LAPS AND SEAMS OF DECK PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS		
	Above	Not exceeding	Diameter of rivets	Type	Breadth		Spacing of rivets centre to centre	Type	Breadth	Spacing of rivets centre to centre
					End lap	Butt strap				
	Inches	Inches	Inches		Inches	Inches	Inches		Inches	Inches
Strength deck stringer plate for ·5L amidships.		·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	*See* note 2		
	·50	·60	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$			
	·60	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$			
	·72	·84	1	Quadruple	14	25	4			
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$			
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5			
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$			
Strength deck stringer plate at ends.		·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	*See* note 2		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$			
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4			
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	4			
	·72	·94	1	Quadruple	14	25	$4\frac{1}{2}$			
Strength deck plating for ·5L amidships.		·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$2\frac{5}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{8}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Quadruple	14	25	4	Double	6	4
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$	$4\frac{1}{2}$
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$	Double	$7\frac{1}{2}$	5
Strength deck plating at ends.		·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	4	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·54	·72	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Treble	$10\frac{1}{2}$	19	$4\frac{1}{2}$	Double	6	4
Strength deck stringer angles.	*See* note 3									

See note 4

NOTES.—TABLE 76 C

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps, the rivet spacing being as given in the Table.

2. In seams of stringer plates the diameter of rivets and number of rows are to be regulated by the thickness of the adjacent deck plating.

3. The stringer angle is to be double riveted over the cargo tanks and for $\frac{1}{3}$B into the poop. The diameter of the rivets is to be governed by the thickness of the angle and the rivets are to be spaced 5 diameters apart in each row. At the ends of the ship the riveting is to be in accordance with Table 19.

4. The seams of strength deck plating at ends clear of oil tanks may be single riveted, and rivets spaced, $4\frac{1}{2}$ diameters.

TABLE 76 D

WELDING AND RIVETING

D

NUMBER OF RIVETS IN SEAMS OF SIDE SHELL PLATING BETWEEN TRANSVERSE FRAMES EXCLUDING RIVETS IN FRAMES

FRAME SPACING	THICKNESS OF SIDE SHELL IN INCHES		
	Not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94
	DIAMETER OF RIVET IN INCHES		
	$\frac{3}{4}$	$\frac{7}{8}$	1
	NUMBER OF RIVETS IN EACH ROW		
Inches			
24	8	6	
$24\frac{1}{2}$	8	6	
25	9	6	
$25\frac{1}{2}$	9	7	
26	9	7	6
$26\frac{1}{2}$	9	7	6
27	9	7	6
$27\frac{1}{2}$	10	7	6
28	10	7	6
$28\frac{1}{2}$	10	7	6
29	10	8	7
$29\frac{1}{2}$	10	8	7
30	11	8	7
$30\frac{1}{2}$	11	8	7
31	11	8	7
$31\frac{1}{2}$	11	8	7
32	11	8	7
$32\frac{1}{2}$		8	8
33		9	8
$33\frac{1}{2}$		9	8
34		9	8
$34\frac{1}{2}$		9	8
35		9	8
$35\frac{1}{2}$		9	8
36		9	8

NOTES.—TABLE 76 D

1. For spacing of rivets clear of cargo tanks and where the form of the ship is curved *see* Table 76 B, note 4.

2. For special requirements in ships above 500 feet in length *see* Table 76 B, note 5.

WELDING AND RIVETING

E

CONNECTIONS OF LONGITUDINALS, FRAMES AND STIFFENERS TO STIFFENING BARS ON PRIMARY SUPPORTING MEMBERS

SECTION MODULUS OF LONGITUDINAL FRAME OR STIFFENER		CONNECTIONS		
		WELDED	RIVETED	
		AREA	NUMBER	DIAMETER
Inches³ Above	Not exceeding	Square inches		Inches
	15	2·0	4	$\frac{3}{4}$
15	25	2·75	4	$\frac{7}{8}$
25	35	3·5	5	$\frac{7}{8}$
35	50	4·0	6	$\frac{7}{8}$
50	70	4·75	7	$\frac{7}{8}$
70	90	5·5	8	$\frac{7}{8}$
90	125	6·25	9	$\frac{7}{8}$

NOTES.—TABLE 76 E

1. **Area of weld** is the product of the throat thickness and the total length of weld, but the throat thickness is not to be less than for a Type 2 weld. (*See* Table 76 A.)

2. The area of weld and number of rivets given in the Table are for bottom and side transverses; for deck transverses the area of weld or number of rivets is not to be less than half the Table value.

3. **Number of rivets** given in the Table (or as modified by note 2) is the minimum; the number fitted is to be sufficient to close the work satisfactorily.

F

BRACKETS AT HEAD OF SIDE FRAMES AND AT ENDS OF VERTICAL STIFFENERS TO LONGITUDINAL BULKHEADS

DEPTH OF FRAME OR STIFFENER	BRACKETS			CONNECTIONS		
				WELDED	RIVETED	
	LENGTH OF ARM	THICKNESS	WIDTH OF FLANGE	AREA	NUMBER	DIAMETER
Inches	Inches	Inches	Inches	Square inches		Inches
6	16	·36		2·5	5	$\frac{3}{4}$
7	18	·36	$2\frac{1}{2}$	3·0	6	$\frac{3}{4}$
8	21	·38	3	3·5	5	$\frac{7}{8}$
9	24	·40	3	4·0	6	$\frac{7}{8}$
10	27	·42	$3\frac{1}{2}$	4·75	7	$\frac{7}{8}$
11	30	·44	$3\frac{1}{2}$	5·5	8	$\frac{7}{8}$
12	33	·46	4	6·25	9	$\frac{7}{8}$

NOTES.—TABLE 76 F

1. **Area of weld** is the product of the throat thickness and the total length of weld, but the throat thickness is not to be less than for a Type 2 weld. (*See* Table 76 A.)

2. **Length of bracket arm** is to be measured from the plating.

3. **Thickness of brackets** at ends of vertical stiffeners on longitudinal bulkheads need not exceed ·44 inch.

TABLE 76 G

WELDING AND RIVETING

G

CONNECTIONS OF PRIMARY SUPPORTING MEMBERS TO

TABLE FACE AREA		POSITION	WELDED TO FACE MATERIAL				
			DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS			
				STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS	
			Type	S or C (All Type 1)	Distance (d) centre to centre	Type	Distance (d) centre to centre
Square inches					Inches		Inches
Above	Not exceeding						
	5·0	For a distance each end equal to ·2 × length		S	$4\frac{1}{2}$	2	$10\frac{1}{2}$
		Remainder		S	7	2	9
5·0	10·0	For a distance each end equal to ·2 × length		C	6	1	12
		Remainder		S	6	2	9
10·0	15·0	For a distance each end equal to ·2 × length	2				
		Remainder	2*				
15·0	20·0	For a distance each end equal to ·2 × length	2				
		Remainder	2*				

* May be Type 3 clear of oil cargo tanks

NOTES.—TABLE 76 G

1. **Length** for use in the above Table is the unsupported length of the member including end connections.

2. The extent of the increased connection at each end equal to ·2 × length given in the above Table is measured from the end of the member including the end bracket, but this length is to be extended as necessary beyond the toe of the bracket, and beyond the heel of the bracket to cover a contiguous member.

3. On vertical webs the increased welding or riveting may be omitted at the top but at the bottom it is to extend for a distance equal to ·3 × length.

WELDING AND RIVETING

G

SHELL, DECK AND BULKHEAD AND TO FACE MATERIAL

WELDED					RIVETED		
TO SHELL, DECK OR BULKHEAD					TO FACE MATERIAL	TO SHELL, DECK OR BULKHEAD	
DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	NUMBER OF ROWS	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
	STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS				
Type	S or C (All Type 1)	Distance (d) centre to centre	Type	Distance (d) centre to centre			
		Inches		Inches			
	C	$4\frac{1}{2}$			7	Double	5
	S	$4\frac{1}{2}$	2	$10\frac{1}{2}$	7	Single	5
2					4	Double	5
	C	5	1	15	6	Double	5
1					5	Double with single riveted backbar.	$4\frac{1}{2}$
2					6	Double	$4\frac{1}{2}$
1					4	Double with single riveted backbar.	4
2					5	Double	4

NOTES.—TABLE 76 G *(concluded)*

4. In ships over 400 feet long the connection of bottom transverses to the shell is not to be less than Type 2 double continuous and that of the side transverses to shell and the vertical webs to longitudinal and transverse bulkheads is not to be less than Type 2 double continuous in the lower half; in riveted ships these connections are not to be less than double riveted angles.

5. Centre line deck and bottom girders are to be welded or riveted as given in the above Table.

6. For particulars of scalloped construction *see* D 4913 and notes under Table 76 A.

TABLE 76 H
(SEE CONTINUATION)

WELDING AND RIVETING

H

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED					RIVETED
	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
		STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS		
	Type	S or C (All Type 1)	Distance (d) centre to centre	Type	Distance (d) centre to centre	
FRAMES & LONGITUDINALS			Inches		Inches	
Side frames to shell — in cargo tanks, spacing not over 30 inches ...		S	6	2	9	6
Side frames to shell — in cargo tanks, spacing over 30 inches ...		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Side frames to shell — in deep, oil fuel and peak tanks		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Side frames to shell — in fore hold		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Side frames to shell — in machinery space, spacing not over 29 inches		S	7	3	$9\frac{1}{2}$	7
Side frames to shell — in machinery space, spacing over 29 inches and up to 32 inches		S	$6\frac{1}{2}$	3	10	$6\frac{1}{2}$
Side frames to shell — in machinery space, spacing over 32 inches and up to 34 inches		S	6	2	9	6
Side frames to shell — in machinery space, spacing over 34 inches ...		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Tween deck frames to shell		S	7	3	$9\frac{1}{2}$	7
Web frames			*See* Table 76 G			
Bottom longitudinals to shell — Where the length L does not exceed 400 ft. — For a distance either side of the bulkhead equal to ·25 × spacing of transverses	2					4
Bottom longitudinals to shell — Where the length L does not exceed 400 ft. — remainder (except in the forward ·25 L)		S	6	2	9	6
Bottom longitudinals to shell — Where the length L exceeds 400 ft. — For a distance either side of bulkhead equal to ·30 × spacing of transverses	2					$3\frac{1}{2}$ with back angle
Bottom longitudinals to shell — Where the length L exceeds 400 ft. — remainder (except in the forward ·25 L)		S	6	2	9	6
Bottom longitudinals to shell — In the forward ·25 L (except at ends of span, where as above)		C	6	1	12	$4\frac{1}{2}$ with back angle
Side longitudinals to shell (*cont. next page*) — Not over 15 ft. below upper deck at side amidships		S	6	2	9	6
Side longitudinals to shell (*cont. next page*) — over 15 ft. and not over 25 ft. below strength deck at side amidships — For a distance either side of bulkhead equal to ·25 × spacing of transverses ...	2*					$4\frac{1}{2}$
Side longitudinals to shell (*cont. next page*) — over 15 ft. and not over 25 ft. below strength deck at side amidships — remainder		S	6	2	9	6

* May be Type 3 clear of oil cargo tanks

For notes see page 228

WELDING AND RIVETING

H (*continued*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED					RIVETED
	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS				MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
		STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOP		
	Type	S or C (All Type 1.)	Distance (d) centre to centre	Type	Distance (d) centre to centre	
			Inches		Inches	
Side longitudinals to shell (*continued*) — Over 25 ft. below strength deck at side amidships — For a distance either side of bulkhead equal to ·25 × spacing of transverses	2					$3\frac{1}{2}$
Side longitudinals to shell (*continued*) — Over 25 ft. below strength deck at side amidships — Remainder...		S	6	2	9	6
Deck longitudinals to deck plating		S	6	2	9	6
Longitudinals to stiffening bars on primary supporting members ...			*See*	Table 76 E		
Bottom frames to shell and floors forward		C	6	1	12	$5\frac{1}{2}$—double riveted
Floors to centre girder forward	1					4—double riveted
Floors and cross ties in fore peak		S	6	2	9	6
Floors and cross ties in aft peak		S	5	2	$9\frac{1}{2}$	5
PRIMARY SUPPORTING MEMBERS						
Bottom transverses to shell			*See*	Table 76 G		
Side transverses to shell						
Deck transverses to deck plating						
Web frames to shell						
Vertical webs on longitudinal bulkheads						
Centre line vertical webs on transverse bulkheads						
Stringers to shell						
Horizontal girders to O.T. bulkheads						
Bottom transverses to longitudinal bulkheads	1					
Deck transverses to longitudinal bulkheads	2					5—double riveted
BRACKETS						
End brackets to all primary supporting members	1					$4\frac{1}{2}$—double riveted except where the transverse is butted on the bracket; when the butt is to be treble riveted
Brackets at head of side frames			*See*	Table 76 F		
Side frames to bilge brackets	To depend on arrangements adopted					
End connections of longitudinals	1—Generally continuous (to depend on design)					
Brackets at ends of vertical stiffeners on longitudinal bulkheads ...			*See*	Table 76 F		
Brackets at ends of stiffeners on transverse bulkheads	To depend on end connections of longitudinals.					
Tripping brackets		S	6	2	9	6
Docking brackets		S	5	2	$9\frac{1}{2}$	5
Stiffening of primary supporting members		S	7	2*	$9\frac{1}{2}$	7

* May be Type 3 clear of oil cargo tanks

For Notes see page 228

TABLE 76H
(CONCLUDED)

WELDING AND RIVETING

H (*concluded*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED					RIVETED
	DOUBLE CONTINUOUS FILLET WELDS	INTERMITTENT FILLET WELDS				
		STAGGERED OR CHAIN		DOUBLE FILLET WITH 6 INCH SCALLOPS		MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
	Type	S or C (All Type 1)	Distance (d) centre to centre	Type	Distance (d) centre to centre	
			Inches		Inches	
O.T. TRANSVERSE & LONGITUDINAL BULKHEADS						
Vertical stiffeners — spacing not exceeding 30 inches		S	6	2	9	6
Vertical stiffeners — spacing exceeding 30 inches		S	$5\frac{1}{2}$	2	9	$5\frac{1}{2}$
Horizontal stiffeners — Not over 15 ft. below highest point of tank ...		S	6	2	9	6
Horizontal stiffeners — on longitudinal bulkheads — over 15 ft. and not over 25 ft. — For a distance either side of bulkhead equal to ·25 × spacing of transverses	2					$4\frac{1}{2}$
Horizontal stiffeners — on longitudinal bulkheads — over 15 ft. and not over 25 ft. — remainder		S	6	2	9	6
Horizontal stiffeners — on longitudinal bulkheads — over 25 ft. — For a distance either side of bulkhead equal to ·25 × spacing of transverses	2					$3\frac{1}{2}$
Horizontal stiffeners — on longitudinal bulkheads — over 25 ft. — remainder		S	6	2	9	6
Horizontal stiffeners — on transverse bulkheads — Not over 18 ft. below highest point of tank		S	6	2	9	6
Horizontal stiffeners — on transverse bulkheads — over 18 ft.		S	5	2	9	5
Boundaries — of longitudinal bulkheads to bottom or deck ...	1					5—double riveted
Boundaries — of transverse bulkheads — to shell at bottom or bilge ...	1					5—double riveted
Boundaries — of transverse bulkheads — to shell at sides or to deck ...	2					5—double riveted
Boundaries — of transverse bulkheads — to longitudinal bulkheads ...	2					5—double riveted
Vertical webs ... ... Horizontal girders		*See* Table 76 G				

NOTES.—TABLE 76 H

1. The requirements of D 31 are to be complied with where applicable except that within the cargo tanks double continuous fillets of Type 3 (Table 76 A) are to be restricted to longitudinal framing and to bulkhead stiffening, and are to have a minimum leg length of ·20 inch.

2. The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three-and-a-half times for rivets 1 inch and above in diameter.

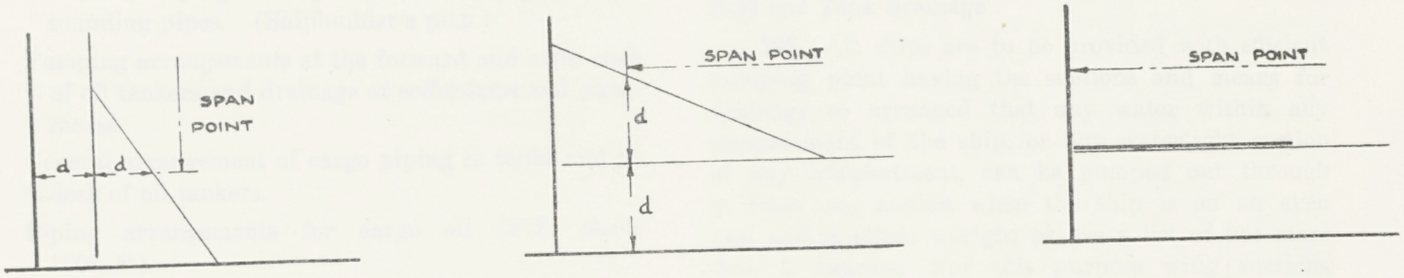
3. The distance from the centre of the rivet hole to the edge of the angle is to be not less than one-and-a-half rivet diameters.

MINIMUM THICKNESS OF STRUCTURE IN CARGO TANKS AND COFFERDAMS

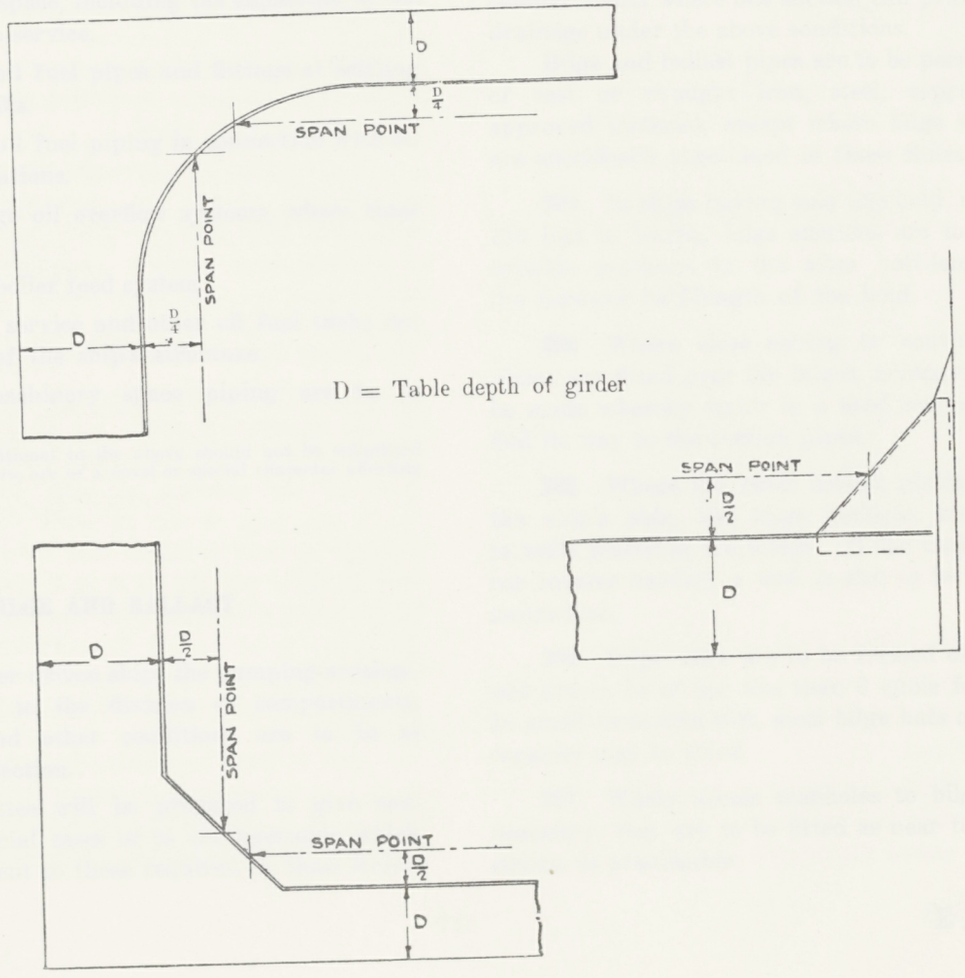
LENGTH L	MINIMUM THICKNESS
Feet	Inches
250	·34
300	·36
400	·38
500	·42
600	·44

SPAN POINT

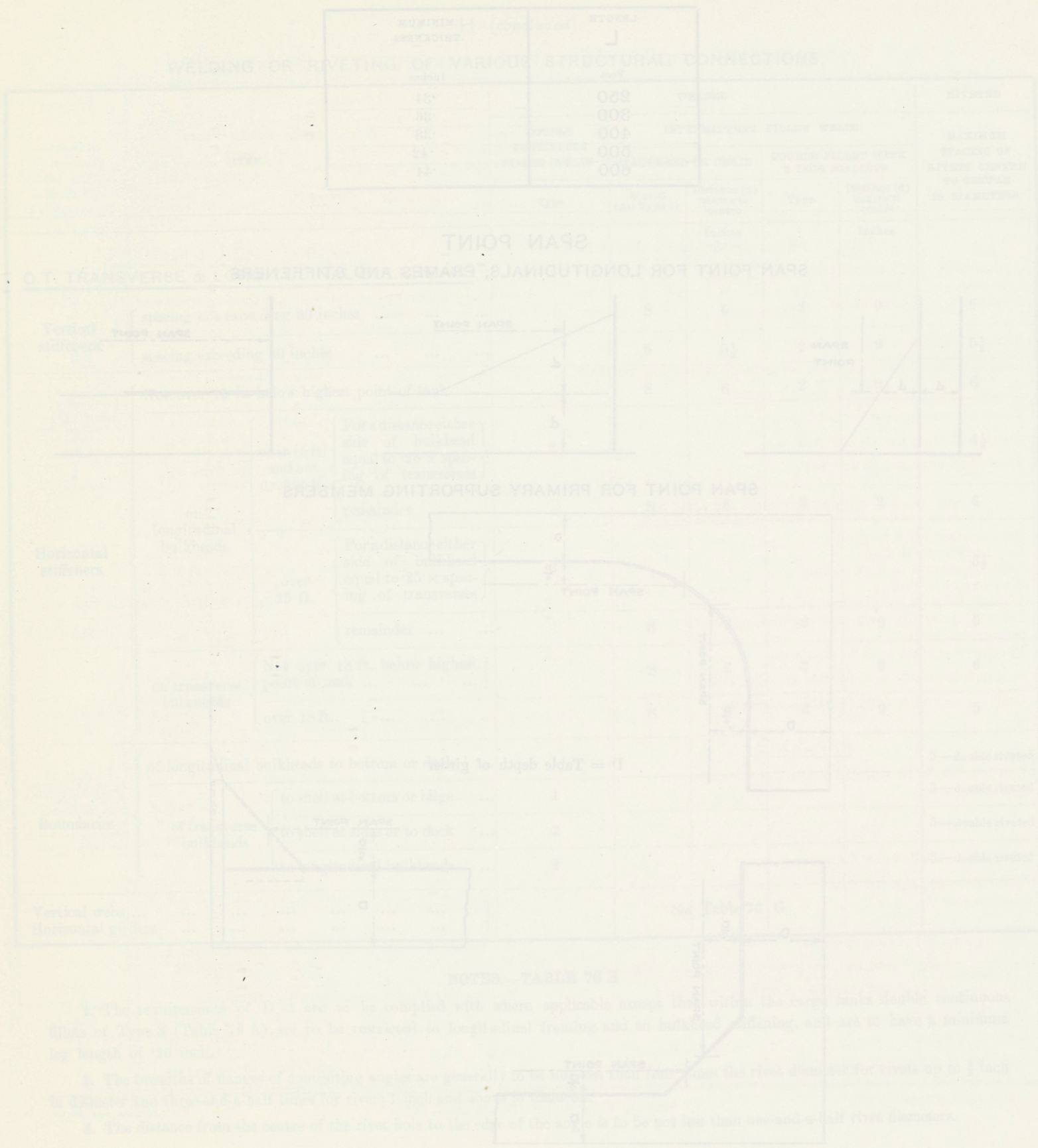
SPAN POINT FOR LONGITUDINALS, FRAMES AND STIFFENERS



SPAN POINT FOR PRIMARY SUPPORTING MEMBERS



D = Table depth of girder



Chapter E

PUMPING AND PIPING

Section 1

PLANS

101 The following plans are to be submitted for consideration :—

General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)

Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

General arrangement of cargo piping in tanks and on deck of oil tankers.

Piping arrangements for cargo oil (F.P. above 150° F.).

Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangement of oil fuel piping in connection with oil burning installations.

Oil fuel and cargo oil overflow systems, where these are fitted.

Arrangement of boiler feed system.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Plans of machinery space piping are to be diagrammatic.

NOTE.—Plans additional to the above should not be submitted unless the arrangements are of a novel or special character affecting classification.

Section 2

BILGE AND BALLAST

General

201 In power driven ships the pumping arrangements according to the division of compartments, rise of floor and other conditions are to be as detailed in this Section.

The Committee will be prepared to give consideration to special cases or to arrangements which are fully equivalent to those required by these Rules.

Consideration will also be given to the pumping arrangements of small ships and ships to be assigned class notations for restricted or special services.

(For pumping arrangements of non-propelled ships, *see* E 11.)

Hold and Tank Drainage

202 All ships are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. For this purpose wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

Bilge and ballast pipes are to be permanent pipes of cast or wrought iron, steel, copper or other approved material, except where bilge suction hoses are specifically mentioned in these Rules.

203 In ships having only one hold, and this over 110 feet in length, bilge suctions are to be fitted in suitable positions in the after half-length, also in the forward half-length of the hold.

204 Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

205 Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings. If the tank top plating has inverse camber, a well is also to be fitted at the centre line.

206 Bilge wells are to be formed of steel plates and are to be of not less than 6 cubic feet capacity. In small compartments, steel bilge hats of reasonable capacity may be fitted.

207 Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

208 Access to the bilge suction strum of a hold well should not be obtained by means of a manhole in the machinery space watertight bulkheads or tank top plating in the machinery space or tunnel if this can be avoided.

Where, however, this arrangement is necessary, the watertight manhole cover should be of hinged type and an instruction plate, in raised letters, should be affixed in a well lighted position, to the effect that this door must be kept shut, except when access is required.

209 The intactness of the machinery space bulkheads, and of tunnel plating which is required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

The tank air pipe is to be led to above the bulkhead deck and provision is to be made for ascertaining the level of water in the tank.

Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

210 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage either by hand or power pump bilge suctions.

If, however, these compartments are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers not less than 1½ inches bore, discharging to the tunnel and fitted with self-closing cocks situated in well lighted and visible positions.

Drainage from Refrigerated Cargo Spaces

211 Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

212 Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed non-return bilge traps.

Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are also to be fitted with liquid sealed traps, but the non-return valves may be omitted if desired. (For insulation of scupper pipes, *see* E 417.)

213 Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

214 The liquid sealed traps are to be of adequate depth and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

215 Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter are not to be fitted.

Where non-refrigerated hatch trunks are intended for the carriage of general cargo while the adjacent spaces in the same hold are intended for the carriage of refrigerated cargoes, details of the draining arrangements for the hatch trunks are to be submitted for special consideration.

216 Screwed plugs or other means for blanking off scuppers draining insulating chambers and cooler trays are not to be fitted.

If, however, it is specially desired by the Owners to provide means for temporarily closing these scuppers, they may be fitted with shut-off valves controlled from readily accessible positions on a deck above the load water line.

Machinery Space—Normal Bilge Drainage

217 The normal bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. One of these suctions is to be a branch bilge suction, i.e., a suction connected to the main bilge line, and the other is to be led direct from an independent power pump or steam ejector. Examples of the necessary arrangements are detailed in 218 to 220.

218 Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

219 Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells of not less than 6 cubic feet capacity, situated one at each side.

220 Where there is no double bottom and the rise of floor is not less than 5 degrees, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

If the rise of floor is less than 5 degrees additional bilge suctions are to be provided at the wings.

221 Where direct bilge suctions are required on both sides of the ship for normal bilge drainage, one of these suctions is to be of a size not less than required for the main bilge line, the other may be of the size required for engine room branch bilge suctions, but the smaller suction is to be fitted on the same side as the emergency bilge suction required by 226 or 227.

222 Additional bilge suctions may be required for the drainage of depressions in the tank top formed by crank pits, or other recesses, by tank tops having inverse camber or by discontinuity of the double bottom.

223 In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for bilge suctions to be fitted in the forward wings as well as the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

224 In ships propelled by electrical machinery, special means are to be provided to prevent the accumulation of bilge water under the main propulsion generators and motors.

225 Where the machinery space is divided by watertight bulkheads to separate the boiler room(s) or auxiliary engine room(s) from the main engine room, the number and position of the main bilge line suctions in the boiler room(s) and auxiliary engine room(s) are to be the same as for cargo holds.

In addition to the main bilge line suctions an independent power pump direct bilge suction, or a steam bilge ejector suction, is to be fitted in each compartment. Similar provision is to be made in separate motor rooms of electrically propelled ships.

The normal drainage arrangements in the main engine room are to be as detailed in 217 to 224.

Machinery Space—Emergency Bilge Drainage

226 In steamers, the main circulating water pump(s) are to be fitted with emergency bilge suction(s), i.e., "bilge injection(s)," which are to be additional to the normal bilge suctions detailed in 217 to 225. These suctions, which are to have a diameter of at least two-thirds that of the sea inlet, are to be led to a suitable low level in the machinery space and are to be fitted with screw-down non-return valves having the spindles so extended that the handwheels are not less than 18 inches above the bottom platform.

In coal burning steamships a flexible bilge hose is to be provided for connecting to the independent power bilge pump. The hose is to have an internal diameter of 4 inches or that required for the main bilge line, whichever is the less, and is to be of sufficient length to reach any part of the engine and boiler room bilges into which coal or ashes could be washed. The lower end of the hose is to be provided with a strainer.

The hose fitting on the pump is to comply with the requirements of 246.

227 In motorships, emergency bilge drainage is to be provided by a bilge ejection led from the main cooling water suction line and of the same size as that line.

Alternatively, the emergency bilge drainage may be provided by a direct bilge suction led from the largest available power pump and is to be of the same size as the suction branch of the pump.

This emergency suction, which corresponds to the bilge injection in steamers, is additional to the normal direct bilge suctions required by 217, and is to comply with the requirements of 226 as regards location and valve arrangements.

The valve nameplate is to be marked "For emergency use only".

Machinery Space—Cooling Water Discharge to Bilges

228 Where a considerable quantity of cooling water is discharged to the machinery space bilges, special arrangements are to be made to deal with this water, in addition to the ordinary bilge pumping arrangements.

Tunnel Drainage

229 The tunnel well is to be drained by a suction from the main bilge line.

230 Where the tank top in the tunnel slopes down from aft to forward, a bilge suction is to be provided at the forward end of the tunnel, in addition to the tunnel well suction required by 229.

Sizes of Bilge Suction Pipes

231 The diameters of bilge suction pipes are to be not less than required by the following formulæ, to the nearest quarter inch :—

MAIN BILGE LINE

$$d_m = \sqrt{\frac{L(B + D)}{2500}} + 1 \qquad (a)$$

In no case is the diameter of the main bilge line to be less than required for any branch bilge suction.

BRANCH BILGE SUCTIONS TO CARGO AND MACHINERY SPACES

$$d_b = \sqrt{\frac{C(B + D)}{1500}} + 1 \qquad (b)$$

where d_m = internal diameter of main bilge line, in inches,

d_b = internal diameter of branch bilge suction, in inches,

L = Rule length of ship, in feet,

B = Rule breadth of ship, in feet,

D = moulded depth to bulkhead deck, in feet,

C = length of compartment, in feet.

No bilge suction pipe is, however, to be less than 2 inches bore.

DIRECT BILGE SUCTIONS, OTHER THAN EMERGENCY SUCTIONS

One of the direct bilge suctions in the main engine room and the direct bilge suctions in large separate boiler rooms, motor rooms of electrically propelled ships and auxiliary engine rooms are to be of a diameter not less than required for the main bilge line.

The other direct bilge suction in the main engine room may, as stated in 221, be of the diameter required for the engine room branch bilge suctions.

Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

EMERGENCY BILGE SUCTIONS

For sizes of emergency bilge suctions, *see* 226 and 227.

232 In oil tankers and similar ships where the engine room pumps do not deal with bilge drainage outside the machinery space, the diameter of the main bilge line may be less than required by 231, formula (*a*) provided the cross-sectional area is not less than twice that required for the branch bilge suctions in the machinery space.

233 The area of each branch pipe connecting the bilge main to a bilge distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

234 The bilge suction pipe to the tunnel well is to be not less than $2\frac{1}{2}$ inches bore, except in ships not exceeding 200 feet in length, in which case it may be 2 inches bore.

Bilge and General Service Pumps

235 Not less than two power operated bilge pumping units are to be provided in the machinery space, one of which may be worked from the main engines. The other unit is to be independently driven.

Each of these units is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of bilge line of not less than 400 feet per minute under ordinary working conditions, but where one unit is of slightly less than this capacity, the deficiency may be made good by an excess capacity of the other unit.

236 TABLE OF CAPACITIES

Bore of bilge pipe in inches	Capacity of each pumping unit in tons/hr.	Bore of bilge pipe in inches	Capacity of each pumping unit in tons/hr.
2	15	$5\frac{1}{4}$	103
$2\frac{1}{4}$	19	$5\frac{1}{2}$	113
$2\frac{1}{2}$	23	$5\frac{3}{4}$	124
$2\frac{3}{4}$	28	6	135
3	34	$6\frac{1}{4}$	146
$3\frac{1}{4}$	40	$6\frac{1}{2}$	158
$3\frac{1}{2}$	46	$6\frac{3}{4}$	171
$3\frac{3}{4}$	53	7	183
4	60	$7\frac{1}{4}$	197
$4\frac{1}{4}$	68	$7\frac{1}{2}$	210
$4\frac{1}{2}$	76	$7\frac{3}{4}$	224
$4\frac{3}{4}$	84	8	239
5	93	$8\frac{1}{4}$	254

237 Each unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is adequate.

238 The steam bilge ejector mentioned in 217 and 243 is not accepted as a substitute for the independent bilge pump required by 235.

Self-Priming Pumps

239 All power pumps which are essential for bilge services are to be of self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

Cooling water pumps having bilge ejection connections need not be of self-priming type.

Pump Connections

240 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

241 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

Direct Bilge Suctions

242 The direct bilge suctions required for normal bilge drainage in the machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

Ejector Suctions

243 Steam bilge ejector suction(s) of similar size to the power pump direct bilge suctions mentioned in 242 may be substituted for the latter, provided the capacity of the ejector be not less than required by 236 and there be adequate means of replenishing the boiler feed water expended as steam by the ejector(s).

If it is desired to employ compressed air or water in lieu of steam for the ejector, details are to be submitted.

Main Bilge Line Suctions

244 Suctions from the main bilge line, i.e., branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment of the ship, excepting small spaces such as those mentioned in 258 and 259, where manual pump suctions are accepted, and are to be of not less size than required by 231, formula (*b*). (For special arrangements for oil tankers, *see* E 1212 to E 1217.)

Pipe Systems and their Fittings

245 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks.

To effect this requirement, the bilge connections to any pump having also suctions from the sea and from tanks should be made either by means of non-return valves or cocks which cannot permit communication between the bilges and the sea or compartments in use as tanks.

246 Screw-down non-return valves are to be provided in the following fittings:—

Bilge valve distribution chests;

Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;

Direct bilge suctions and bilge pump connections to main bilge line.

247 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to either a bilge, ballast or oil line.

248 Suctions for normal bilge drainage in machinery spaces and tunnels are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit of their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes.

249 The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels, are to be enclosed in strum boxes having perforations not more than $\frac{3}{8}$ inch diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

The distance between the foot of all bilge tail pipes and the bottom of the bilge or well is to be adequate to allow a full flow of water and to facilitate cleaning.

250 All cocks and valves in connection with bilge, ballast and fresh water suction pipes are to be fitted with legible nameplates, and, unless otherwise specifically mentioned in the Rules, are to be fitted in places where they are at all times readily accessible.

251 Bilge cocks, valves and mud boxes are to be fitted at, or above, the machinery space and tunnel platforms.

Where it is not practicable to avoid the fittings being situated at the starting platform or in passageways, they may be situated just below the platform, provided readily removable traps or covers are fitted and nameplates indicate the presence of these fittings.

If relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform.

252 Bilge suction pipes are not to be carried through double bottom tanks if it is possible to avoid doing so.

Bilge pipes which pass through these tanks are to be of substantial strength and are to be tested, after fitting, to the same pressure as the tanks through which they pass.

253 In way of deep tanks for water ballast, fresh water, oil fuel or cargo oil, bilge pipes should preferably be led through pipe tunnels, but where this is not done, the pipes are to be of steel of heavy gauge and fitted in one length, if practicable, or with welded joints.

Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the open ends of the bilge suction pipes in the holds are to be fitted with non-return valves of the special type approved for use in holds (*see* 265).

Tank piping, other than that of the deep cargo tank pumping system, is not to be situated within deep cargo oil tanks.

The pipes are to be tested, after fitting, to a pressure not less than the maximum head to which the tanks can be subjected.

254 Bilge, ballast and cooling water suction and discharge pipes are to be made in readily removable lengths with flanged joints, except as mentioned in 253, and are to be efficiently secured in position to prevent chafing or lateral movement.

Long or heavy lengths of pipes are to be supported by bearers so that no undue load is carried by the flanged connections of the pumps or fittings to which they are attached.

Where lack of space prevents the use of normal circular flanges, details of the alternative methods of joining the pipes are to be submitted.

255 Suitable provision for expansion is to be made in each range of pipes and where the connections at bulkheads and other structural parts of the ship are made with lead bends, the radii of the bends and the distance between the axes of the straight parts of the pipe are each to be not less than three diameters and the length of the bend is to be at least eight diameters of the pipe.

256 Bilge suction pipes of lead are not permissible in engine rooms, boiler rooms or other compartments in which oil fuel storage tanks, cargo oil tanks or oil fuel appliances are situated. Nor are they to be used within coal bunkers or attached to bunker bulkheads or oil tanks.

Fore and After Peak Drainage

257 Where the peaks are used as tanks, a separate power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, when hand pumps may be used.

258 Where the peaks are not used as tanks and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided the suction lift be well within the capacity of the pumps and in no case exceeds 24 feet.

259 Provision is to be made for the drainage of the chain locker and the watertight flat above the fore peak tank by hand or power pump suction. (For drainage of the flat above the after peak tank, *see* 210.)

260 Where a suction pipe is led from the engine room to the fore peak, either through a hold space or through a tank intended to carry oil fuel, it is to be provided with a screw-down valve capable of being operated from an accessible position above the bulkhead deck, the chest being secured to the collision bulkhead inside the fore peak. An indicator is to be provided to show whether the valve is open or shut.

Watertight Bulkhead and Tunnel Fittings

261 No drain valve or cock is to be fitted to the collision bulkhead.

262 Drain valves or cocks are not to be fitted to other watertight bulkheads, if alternative means of drainage are practicable.

Where fitted, the valves and cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut. (For drainage of stern compartments, *see* 210.)

263 Valve chests, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts and not by bolts passing through clearance holes.

Alternatively, the studs or the bulkhead piece may be welded to the plating.

Deep Tanks

264 In the case of deep tanks which may be used for either water ballast or dry cargo, provision is to be made for blank flanging the water ballast filling and suction pipes when the tank is being used for the carriage of dry cargo and for blank flanging the bilge suction pipes when the tank is being used for the carriage of water ballast.

Change-over devices may be used for this purpose. (For arrangements when oil fuel or cargo oil is carried in deep tanks, *see* E 320.)

Hold Bilge Valves

265 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

Ship Side Valves (other than those on Scuppers and Sanitary Discharges)

266 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating. These fittings are to be secured by bolts tapped into the plating and fitted with countersunk heads or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the plating.

Distance pieces of short rigid construction, and made of approved material as required by 270, may be fitted between the valves and shell plating. Distance pieces of steel may be welded to the shell plating. Details of the welded connections and of fabricated steel water boxes are to be submitted.

267 All suction and discharge valves and cocks direct on the shell plating of the ship are to be fitted with spigots passing through the plating, but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating.

Blow-down cocks or valves are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

268 Blow-down cocks or valves on the ship's side are to be fitted in accessible positions above the level of the working platform and are to be arranged so that it can be readily seen whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut, and if valves are fitted, the wheels are to be fixed to the spindles.

269 Sea inlet and overboard discharge cocks and valves are in all cases to be fitted in easily accessible positions and, as far as practicable, are to be readily visible.

The inlet valve spindles are to extend above the lower platform, and the hand wheels of the main injection and bilge injection valves are to be situated not less than 18 inches above this platform.

270 Where valves or cocks are over 3 inches bore, they are to be of steel or an approved grade of cast iron or other approved material; this requirement applies equally to inlet chests, distance pieces, and other sea connections.

All these fittings, if made of steel, are to be suitably protected against wastage.

271 In ships having a notation for ice strengthening, the sea inlet and overboard discharge valves which are situated below the maximum load line are to be provided with connections from the boilers or compressed air receivers for clearing purposes. Low pressure steam or air is to be used for this purpose.

272 The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

Miscellaneous Requirements

273 All pipes situated in cargo spaces, coal bunkers, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected. (*See* D 2519, quoted at end of this Section, and D 2412, quoted at end of E 4.)

274 Wash deck pipes and discharge pipes from the pumps to domestic water tanks are not to be led through cargo holds if, as is generally the case, it is practicable to avoid doing so. Any proposed departure from this requirement is to be submitted.

275 As far as practicable, pipe lines, including exhaust pipes from oil engines, are not to be led in the vicinity of switchboards or other electrical appliances in positions where drip or escape of liquid, gas or steam from joints or fittings may cause damage to the electrical installation.

Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

Short sounding pipes to tanks should not terminate near electrical appliances (*see* E 413).

Extract from Chapter D for reference

Scuppers

D 2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

D 2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

D 2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

D 2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down non-return valves as required by 2510.

D 2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

D 2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

D 2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

D 2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

D 2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

D 2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

D 2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

Protection of Pipes and Valves

D 2519 In all cargo spaces or coal bunkers scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Section 3

OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 150° F.

General

301 In addition to the special requirements detailed in this Section, the requirements of E 2 relating to bilge and ballast are to be complied with in so far as they are applicable to the drainage of tanks, oil bilges and cofferdams.

Oil Fuel Pumps and Oil Burning Appliances

302 In every ship where steam for the main propelling engines, or for auxiliary machinery which is required for essential services, is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, a suction filter, a discharge filter and a heater.

In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services.

In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

303 Unit pressure pumps for the oil burning system are to be entirely separate from the feed, bilge or ballast systems.

304 In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipe line to the burners and so arranged that one filter can be opened up when the other is in use.

305 If oil fuel is sprayed by steam, means are to be provided to carry or make up the fresh water used for this purpose.

306 A starting-up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting-up device, which does not require power from shore, is to be provided.

307 All pumps used in connection with oil fuel are to be provided with effective escape valves which are to be in close circuit, i.e., discharging back to the suction side of the pumps.

Escape valves are also to be fitted on the oil side of the heaters, discharging to the pump suction line, to the tray under the unit, or to other approved position, and are to be adjusted to operate at a pressure of 50 lb. per square inch above that of the pump escape valve.

308 Where a power driven transfer pump is necessary for pumping up the settling tanks in motorships and steamships, a stand-by pump is to be provided and connected ready for use, or alternatively, emergency connections may be made to one of the unit pumps or to another suitable power driven pump.

Oil Pipes and Fittings

309 Pipes conveying heated oil under pressure are to be of seamless steel having flanged couplings and placed in sight above the platform in well lighted parts of the stokehold or engine room.

The flanges are to be machined and the jointing material, which is to be impervious to oil heated to 250° F., is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for at least 200 lb. per square inch working pressure, or the pressure to which the relief valves are adjusted, whichever is the greater.

The pipes, heaters and their fittings are to be tested after jointing to not less than 400 lb. per square inch, or twice the working pressure, whichever is the greater.

The thickness of the oil fuel pressure pipes is to be determined from the formula contained in E 512.

310 The short joining lengths of pipes to the burners from the control valves on the boiler front may have cone unions of specially robust construction.

Flexible pipes of approved material and design may be used for the burner pipes provided spare lengths, complete with couplings, be carried on board.

A quick closing master valve is to be fitted on the hot oil supply to each boiler manifold.

311 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast or wrought iron or steel, having flanged joints suitable for a working pressure of not less than 100 lb. per square inch. The flanges are to be machined and the jointing material is to be impervious to oil. Oil pipes within the engine and boiler spaces are to be fitted where they can be readily inspected and repaired, and after jointing they are to be tested to 50 lb. per square inch, or twice the maximum working pressure, whichever is the greater.

Valves and Cocks

312 The valves, cocks and their pipe connections are to be so arranged that oil cannot be admitted into tanks which are not structurally suitable for the carriage of oil or into tanks which can be used for the carriage of fresh water intended for boiler feed or for drinking.

313 All oil suction pipes are to be fitted with valves or cocks at or near the bulkheads where they enter the engine and boiler space, unless the pipes are already provided with readily controlled shut-off valves outside this space.

314 The outlet valves or cocks at all oil storage, settling and daily service tanks, other than double bottom tanks, are to be secured to the tanks and so geared that they may be shut off from positions which will always be accessible in the event of fire taking place in the compartment in which they are situated. Indicators are to be provided at the valves and on deck to show whether the valves or cocks are open or shut.

In the case of fore peak tanks, these valves are to be fitted on the tank side of the bulkhead, and in the case of after peak tanks, in the tunnel or inside the tanks.

315 All valves and cocks in the machinery space forming part of the oil fuel installation are to be capable of being controlled from above the engine and boiler room platforms, and oil fuel valves are to be so constructed as to prevent the possibility of any cover being slacked back or loosened when operating the valves. The cocks and valves are to be fitted with legible nameplates.

316 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

317 Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in the case of the outlet valves or cocks on these tanks.

318 Open drains for removing the water from oil tanks are to be fitted with cocks or valves of self-closing type and suitable provision is to be made for collecting the oily discharge.

Alternative Carriage of Oil Fuel and Water Ballast

319 Where it is intended to carry oil fuel and water ballast in the same compartments alternatively, the valves or cocks connecting the suction pipes of these compartments with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from any one compartment by the oil fuel pump at the same time as the ballast pump is being used on any other compartment.

Where settling or service tanks are fitted each having a capacity sufficient to permit of 12 hours' normal service without replenishment, the above requirement may be dispensed with.

Deep Tanks for the Alternative Carriage of Oil, Water Ballast or Dry Cargo

320 In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam heating coils if retained in place, when the tank is used for dry cargo and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

If the deep tanks are connected to an overflow system, the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

Oily Bilge Drainage and Sediment Suctions

321 Provision is to be made for the drainage of oil gutterways, oil wells and cofferdams. (*See* D 2024 to D 2027, quoted at end of this Section.)

Fresh Water Piping

322 Pipes in connection with compartments used for storing boiler feed water are to be separate and distinct from any pipes which may be used for oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

Similar precautions are necessary when the connections are such that fresh water carried in other tanks can be used as reserve feed water.

Service, Settling and other Oil Fuel Tanks

323 In general, the minimum thickness of the plating of these tanks, when they do not form part of the structure of the ship, is to be $\frac{1}{4}$ inch, but in the case of very small tanks, the minimum thickness may be $\frac{1}{8}$ inch. Adequate stiffening of the plating is to be provided where necessary.

On completion the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected but not less than 8 feet above the crown of the tank.

Water Drainage from Settling Tanks

324 Settling tanks are to be provided with means for draining water from the bottom of the tanks.

If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains (*see* 318).

Ventilation

325 The spaces in which the oil fuel burning appliances, and the oil fuel settling and service tanks are fitted, are to be well ventilated and easy of access.

Boiler Insulation and Air Circulation in Boiler Room

326 The boilers are to be suitably lagged. The clearance spaces between the boilers and tops of the double bottom tanks and between the boilers and the sides of the storage tanks in which oil fuel or cargo oil is carried, are to be adequate for the free circulation of air necessary to keep the temperature of the stored oil well below its flash point.

327 Where water tube boilers are installed, there should be a space of at least 2 feet 6 inches between the tank top and the underside of the pans forming the bottom of the combustion spaces.

328 Smoke-box doors are to be shielded and well fitting, and the uptake joints made airtight.

Funnel Dampers

329 Dampers which are capable of completely closing the gas passages are not to be fitted to inner funnels of ships equipped for burning oil fuel only. In ships burning oil or coal alternatively, dampers may be retained if they are provided with a suitable device whereby they may be securely locked in the fully open position.

Steam Heating Arrangements

330 Where steam is used for heating oil fuel, cargo oil or lubricating oil, either in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil (*see* E 1218).

331 The steam heating pipes in contact with oil are to be of cast or wrought iron or of steel and are to be tested, after being fitted on board, to twice the maximum pressure to which they can be subjected.

332 The working pressure of steel steam heating pipes is to be determined from the formula in E 512.

Control of Pumps

333 The power supply to the oil fuel transfer and unit pressure pumps and to the cargo oil pumps is to be capable of being stopped from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated, as well as from the compartment itself.

Precautions against Fire

334 Settling and daily service oil fuel tanks and oil fuel filters are not to be situated immediately above boilers or other highly heated surfaces.

335 Oil fuel pressure pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

336 Short sounding pipes to oil fuel tanks are not to be situated adjacent to boilers or to electric generators or motors. (For alternative sounding arrangements, *see* E 411.)

337 Water service pipes and hoses are to be fitted in order that the floor plates and tank top or shell plating in way of boilers, oil fuel apparatus or deep storage tanks in the engine and boiler spaces can at any time be flushed with sea water.

338 So far as is practicable the use of wood is to be avoided in the engine rooms, boiler rooms and tunnels of ships burning oil fuel.

339 Drip trays are to be fitted at the furnace mouths to intercept oil escaping from the burners and under all other oil fuel appliances which require to be opened up frequently for cleaning or adjustment. The arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off.

Separation of Cargo Oils from Oil Fuel

340 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing these cargo oils. (*See* D 2105, quoted at end of this Section.)

Oil Drainage in way of Refrigerated Cargo Chambers

341 The insulation of all oil storage tank tops is to have an air space of 2 inches provided between the under side of the insulation and the tank top plating and the supporting battens are to be arranged athwartship to permit of free drainage to the bilges. As an alternative to the air space, approved inodorous material not less than $\frac{1}{2}$ inch in thickness may be laid on the tank top plating.

342 A cofferdam is to be fitted separating deep tanks intended for the carriage of oil from refrigerated compartments unless the tank bulkhead is wholly welded including its boundary connections, in which case the cofferdam may be omitted and an air space of not less than 2 inches arranged between the insulation and the bulkhead plating to provide for free drainage from the latter into the oil gutterway and thence to the bilges.

Provision is to be made for ventilating the cofferdam or air space, the vents being led to the open air and their outlets being fitted with a wire gauze diaphragm which can easily be removed for renewal.

Extracts from Chapter D for reference

Protection and Drainage

D 2023 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

D 2024 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

D 2025 Where a bulkhead, including its boundary connections, is wholly welded, the requirements of 2024 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

D 2026 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than $\frac{1}{2}$ inch in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

D 2027 Drip trays or gutterways, with suitable draining arrangements, are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

D 2028 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Vegetable and Similar Oils

D 2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water, by a cofferdam.

Section 4

AIR, OVERFLOW AND SOUNDING PIPES

Air and Overflow Pipes

401 Air pipes are to be fitted at the outboard corners of tanks at the opposite end of the tank to that at which the filling pipes are placed and/or at the highest part of the tank.

Where the tank top is of unusual or irregular profile, special consideration will be given to the number and position of the air pipes.

Where a single air pipe is fitted it is not to be used as a filling pipe.

Nameplates are to be affixed to the upper ends of all air pipes.

402 Air pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea are to be led to above the bulkhead deck.

Air pipes to oil fuel and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open. (For height of air pipes above deck, *see* D 2409, quoted at end of this Section.)

403 The open ends of air pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled and each opening is to be furnished with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning or renewal.

404 Arrangements are to be made to prevent excessive pressure coming on the tanks in the event of positive closing appliances being fitted to the upper ends of those air pipes which also serve as overflow pipes. Details of these precautionary arrangements are to be submitted.

405 In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the air pipes to each tank or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

In wire gauze diaphragms at air pipe openings, the area of the clear opening is to be not less than the cross-sectional area required for the pipe.

Air pipes are to be not less than 2 inches bore.

406 The arrangement of the overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

Air and overflow pipes are to be arranged to be self-draining under normal conditions of trim.

407 If an overflow system is provided for the oil fuel storage or cargo oil tanks, the discharge from this system is to be led to an overflow tank.

Overflows from settling or daily service tanks are to be led back to the storage tanks or to an overflow tank.

A sight glass is to be provided in the overflow pipe to indicate when the tanks are overflowing or, alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

Overflow tanks which are the only means of relieving the storage tanks of undue pressure are to be of sufficient capacity to take 10 minutes' flow at the normal rate of loading.

408 Where overflows from tanks which are used for the alternative carriage of oil and water ballast are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing into tanks containing oil (*see* also E 320).

409 Air and overflow pipes are to be of steel or wrought iron and should have a minimum thickness of ·19 inch. Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

Sounding Pipes

410 Provision is to be made for sounding all tanks, and the bilges of those compartments which are not at all times readily accessible.

The soundings are to be taken as near the suction pipes as practicable.

411 Tank sounding devices will be accepted in lieu of sounding pipes, provided details of the devices have been submitted for consideration and accepted by the Committee. These devices are to be tested, after fitting on board, to the satisfaction of the Surveyors.

412 Sounding pipes, including those for the double bottom tanks below the machinery spaces, should be led to positions above the bulkhead deck which are at all times accessible.

These pipes should be as straight as practicable, and if curved to suit the structure of the ship, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.

Nameplates are to be affixed to the upper ends of all sounding pipes.

413 In machinery spaces and tunnels where it is not always practicable to extend the sounding pipes as mentioned in 412, short sounding pipes extending to readily accessible positions above the platform may be fitted, provided those to oil fuel and lubricating oil tanks are not situated adjacent to boilers or electric generators or motors, and are fitted with cocks having parallel plugs with permanently attached handles so loaded that, on being released, they automatically close the cocks.

Short sounding pipes to tanks other than oil tanks are to be fitted with shut-off cocks or with screw caps attached to the pipes by chains.

414 Neither round gauge glasses nor test cocks are to be used for ascertaining the level of oil in storage, settling or service tanks, but suitably protected gauges of approved design, having flat glasses of substantial thickness and self-closing cocks or valves, may be fitted on shallow settling or service tanks.

415 Sounding pipes to oil compartments are not to terminate within refrigerated cargo chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms, if it be practicable to avoid doing so.

Where these sounding pipes do terminate in such spaces they are to be fitted with self-closing cocks having parallel plugs.

416 Sounding pipes are to be not less than $1\frac{1}{4}$ inches bore. Where sounding pipes pass through refrigerated spaces, or the insulation thereof, in which the temperatures contemplated are 32°F. or below, they are to be not less than $2\frac{1}{2}$ inches bore.

417 All pipes, including scupper pipes, air pipes and sounding pipes which pass through chambers intended for the carriage or storage of refrigerated produce are to be well insulated.

Where such pipes pass through chambers intended for a temperature of 32°F. or below they are also to be insulated from the steel structure except in positions where the temperature of the structure is mainly controlled by the external temperature and will normally be above freezing point. Pipes passing through a deck plate within the ship side insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deck plating.

In the case of pipes adjacent to the shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as far as practicable.

The air refreshing pipes to and from refrigerated compartments need not, however, be insulated from the steel work.

418 Sounding pipes are to be of steel or wrought iron and should have a minimum thickness of ·17 inch. Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

419 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

When slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

420 Elbow sounding pipes are not to be used for deep tanks unless the elbows are situated within closed cofferdams or within tanks containing similar liquids.

They may, however, be fitted to other tanks and may be used for sounding bilges, provided it is not practicable to lead them direct to the tanks or compartments.

The elbows are to be of heavy construction and adequately supported.

421 The internal lengths of short sounding pipes are not to be arranged for the escape of air or vapour from the tanks into the compartments in which they are situated.

Extract from Chapter D for reference

Air and Sounding Pipes

D 2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather, is to be as follows :—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship, with the depth D measured to that deck ... ... 36 inches.

On raised quarter decks ... ... 30 inches.

On superstructure decks other than raised quarter decks, but including those extending for the full length of the ship ... ... 18 inches.

D 2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

D 2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

D 2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 5

PRESSURE PIPES

Copper Pipes

501 Pipes made from the electro-deposition of copper on a mandril are not to be used.

502 Pipes are to be carefully annealed on completion and prior to testing by hydraulic pressure.

503 All pipes which are subject to a working pressure over 75 lb. per square inch are to be seamless.

504 Steam pipes intended for a working pressure over 180 lb. per square inch are not to be of copper when the internal diameter exceeds 5 inches.

505 Copper pipes are not to be used for a temperature above 425° F.

506 The working pressure to be allowed on copper pipes is to be determined by the following formula :—

$$WP = \frac{(t-3) \times F}{d} \text{ or } t = \frac{WP \times d}{F} + 3$$

where WP = working pressure, in lb. per square inch, which, in the case of feed pipes, is to be taken as 1·25 times the boiler pressure,

d = internal diameter, in inches,

t = thickness, in 100ths of an inch,

F = 60 for seamless pipes,
45 for brazed pipes.

507 Where copper pipes are bent, they are to be made thicker by 1 S.W.G. (approximately ·02 inch) than required by 506 to provide for thinning at the bend.

In no case is the radius of curvature at the centre line of the pipe to be less than twice the external diameter of the pipe.

Steel Pipes

508 Steel pipes are to comply with the material requirements of P 13. For alloy steels particulars of chemical composition, deoxidising mediums and operating temperature are to be submitted for approval. Similar particulars are also to be submitted for carbon steel where the proposed operating temperature exceeds 750°F. The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

509 Pipes of seamless or other approved type are to be used for feed pipes, for pressure pipes conveying heated oil and for other pressure pipes where the working pressure exceeds 250 lb. per square inch or the temperature exceeds 425°F.

510 Pipes other than those mentioned in 509 may be lap welded provided they are made by an approved mechanical process.

511 Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 50 lb. per square inch.

512 The thickness of steel pipes intended for steam, feed, air, oil fuel and other pressure services is to be determined by the following formula and the thickness so obtained is suitable for straight pipes and pipes which are to be bent.

The formula does not provide for adverse corrosion conditions and steam and feed pipes over 1 inch bore intended for use with low presssure boilers (up to 250 lb. per square inch working pressure) and any boilers with open feed systems are to be made one gauge (about ·02 inch) thicker than required by the formula.

The formula also makes provision for a manufacturing tolerance of −15 per cent and where tubes are specified to a closer negative tolerance than this figure, the rule thickness may, if desired, be reduced to suit the specified tolerance.

Seamless pipes for all pressures and temperatures:

$$t = \left(\frac{WP \times D}{2f} + \cdot 05\right) 1{\cdot}275$$

(For lap welded pipes for pressures up to 250 lb. per square inch and temperatures up to 425°F. the thickness is to be 50 per cent greater than required for seamless pipes).

Where t = thickness of pipe, in inches,

WP = working pressure, in lb. per square inch.

For feed pipes, WP is to be taken as 1·25 times the boiler pressure, or the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

With water tube boiler installations, WP is to be taken as the approved boiler pressure for steam pipes between the boiler and integral superheater and as the pressure to which the superheater safety valves are set for the steam pipes leading from the superheater. Where the superheater safety valves are controlled by pilot valves operated from the saturated steam drum then WP for the steam pipes leading from the superheater is to be taken as the boiler pressure.

NOTE.—In installations where the boiler pressure, as controlled by the safety valve settings, is less than the approved boiler pressure it will be permissible for thicknesses of external steam and feed pipes to be based on the former.

D = outside diameter of pipe, in inches,

f = nominal stress in lb. per square inch with the following values:—

For temperatures up to and including 650° F.
f is to be taken as $\frac{1}{5}$ of the specified minimum tensile strength of the pipe material. Values of f are given in the first column of Table 1 for representative carbon steels and may be obtained on the foregoing basis for any other carbon or low alloy pipe steel approved for pressure service.

For temperatures above 650° F.
f is to be taken from Table 1 which gives values of f for a limited number of pipe steels of approved composition in common use for superheated steam pipe service. Values of f for other steels will receive special consideration.

Steam temperature is to be taken as the designed operating temperature for the pipe line provided the temperature at the superheater outlet is closely controlled. Where temperature fluctuations exceeding 25° F. above the designed temperature are to be expected in normal service the steam temperature for use with the Table is to be increased by the amount of this excess.

For intermediate temperatures, values of f may be obtained by interpolation.

Where it is proposed to use, for high temperature service, alloy steels other than those stated in the Table, particulars of tube sizes, working conditions and appropriate British or other national standard material specification giving the data required by 508 are to be submitted for consideration.

TABLE 1

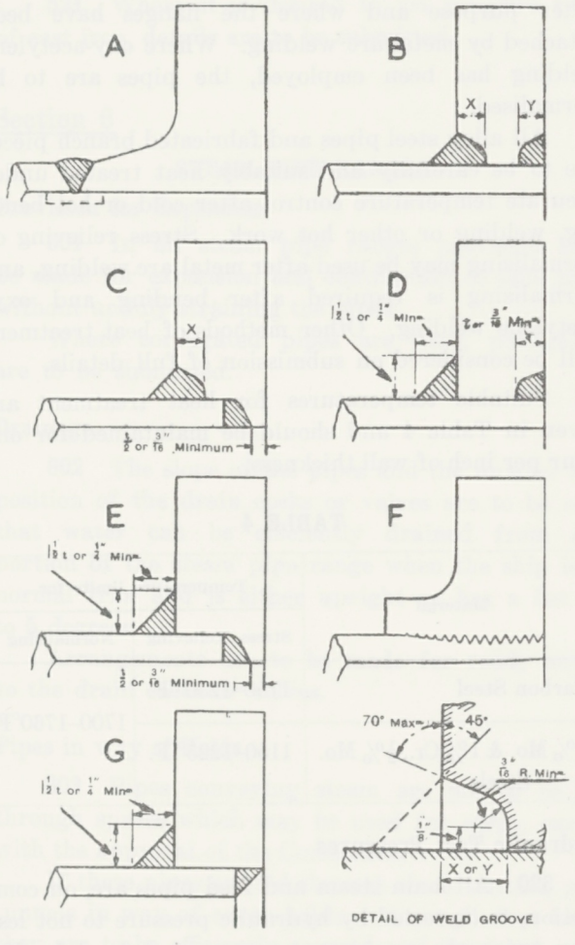
PIPE STEELS		STEAM TEMPERATURE °F.							
TYPE	Minimum tensile strength tons per square inch	650	700	750	800	850	900	950	1000
		Values of f = Nominal stress in lb. per square inch							
Carbon	23	10300	9800	9200	8400	7600	5000		
	27	12100	11500	10800	9300	7600	5000		
½% Mo.	25	11200	11200	11200	11000	10800	10400	7200	
	28	12500	12500	12500	12400	12100	11000	7200	
1% Cr., ½% Mo. ...	27	12100	12100	12100	12100	11800	11200	7800	3600

Where the material does not conform to an established standard, particulars of chemical composition, deoxidising medium, heat treatment, mechanical properties and measured or estimated long term creep and rupture data at the proposed operating temperature are to be submitted for the purpose of assessing a safe working stress.

Steel Pipe Flanges and Branch Pieces

513 Flanges are to be weldless and of material suitable for the working temperature. They may be attached to pipes by screwing and expanding or by welding. Acceptable methods of attachment are illustrated and Table 3 indicates the pressures and temperatures for which the various types are acceptable.

ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL PIPES



If backing rings are used with flange type A they are to fit closely to the bore of the pipe. The rings are to be made of the same material as the pipes or of good quality mild steel having a sulphur content not greater than 0·06 per cent. Flange types C and E are unsuitable for pipes under 3 inches bore.

Alternative methods of flange attachment and other types of pipe joints may be accepted provided details are submitted for special consideration.

For flange types B and C, dimension X is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than shown in Table 2.

For flange type B, dimension Y is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than $\frac{3}{16}$ inch.

t is to be taken as the rule thickness of the pipe.

TABLE 2

Pipe Bore	Dimension X Minimum
$\frac{1}{2}''$ and $\frac{3}{4}''$	$\frac{1}{4}''$
$1''$ to $1\frac{1}{2}''$	$\frac{5}{16}''$
$2''$ and over	$\frac{3}{8}''$

TABLE 3

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure lb. per sq. in.	Temperature °F.	Pressure lb. per sq. in.	Temperature °F.
A, B & C	All Conditions			
D & E	750	500	550	750
F	600		450	
G	250		250	500

514 Where flanges are attached by screwing, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed portion of the pipe over the thread must not be appreciably less than the outside diameter of the unscrewed pipe. After the flange has been screwed hard home the pipe is to be expanded into the flange.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

515 When flanges are attached by welding using the oxy-acetylene or metal arc process the filler rods and electrodes used are to be suitable for the materials of the parts to be joined.

In general oxy-acetylene welding is suitable only for flange type A and is not to be applied to pipes exceeding 4 inches diameter or $\frac{3}{8}$ inch thick.

Preheating is to be employed when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. Particulars are to be submitted.

Where butt welds are employed in the attachment of flange type A or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding, or machining provided the pipe wall is not reduced below the designated thickness.

Butt welds are to be reinforced externally by additional runs of weld metal. All welds in high pressure and high temperature pipe lines are to have a smooth surface and even contour; if necessary they are to be made smooth by grinding. No undercutting of the pipe at the edges of the weld is acceptable.

516 Branches may be attached to pressure pipes by means of welding provided the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively the thicknesses of pipe and branch are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

517 The welding procedure proposed for the attachment of flanges to pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of a pipe section with welded-on flange or attached branch pipes will be required for examination and test.

Sections are to be taken from the joints at selected positions and are to be macro-etched to ascertain that welds are free from cracks, inclusions and cavities. In the case of pipes or branch pieces of alloy steel mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength. Check tests are to be carried out periodically at the Surveyor's discretion.

518 All welds attaching flanges and branches to alloy steel pipes of 3 inches bore and over are to be examined to ensure as far as possible that the welds are satisfactory. These examinations are to be carried out by radiography where practicable or by other approved methods. Defects, if found, are to be cut out and the seam rewelded and re-examined.

Heat Treatment of Steel Pipes and Branch Pieces

519 Carbon steel pipes intended either for pressures above 150 lb. per square inch or temperatures above 500° F. are to be stress relieved where they have been heated for bending the pipe or for any other purpose and where the flanges have been attached by metal arc welding. Where oxy-acetylene welding has been employed, the pipes are to be normalised.

All alloy steel pipes and fabricated branch pieces are to be carefully and suitably heat treated under accurate temperature control after cold or hot bending, welding or other hot work. Stress relieving or normalising may be used after metal arc welding, and normalising is required after bending and oxy-acetylene welding. Other methods of heat treatment will be considered on submission of full details.

Suitable temperatures for heat treatment are given in Table 4 and should be maintained for one hour per inch of wall thickness.

TABLE 4

Material	Temperature limits for	
	Stress Relieving	Normalising
Carbon Steel	1150–1250° F.	1700–1760° F.
$\frac{1}{2}$% Mo. & 1% Cr., $\frac{1}{2}$% Mo. Steels	1150–1225° F.	

Hydraulic Test Pressures

520 All main steam and feed pipes are, on completion, to be tested by hydraulic pressure to not less than twice the working pressure as defined in 506

and 512. Other pipes are to be similarly tested when intended for working pressures above 150 lb. per square inch.

In the case of superheat steam pipes and fabricated branch pieces a test pressure (TP) is to be applied so that these parts are subjected, under hydraulic test, to approximately the same wall stress as saturated steam pipes. The hydraulic test pressure is to be as follows, but need not be more than 4,500 lb. per square inch.

$$TP = 2\,WP \times \frac{f \text{ at } 650^\circ \text{ F.}}{f \text{ at working temperature}}$$

Where f is obtained from Table 1.

For the testing of the completed oil fuel pipes and heating coil systems after fitting on board *see* E 309, E 311 and E 331.

Cast Iron Pipes

521 Where it is desired to use pressure pipes of cast iron, details are to be submitted.

Section 6

STEAM PIPE RANGES

Provision for Expansion

601 In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

Drainage

602 The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to 5 degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

Pipes in way of Holds

603 Pipes conveying steam are not to be led through spaces which may be used for cargo, except with the approval of the Committee.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

Reduced Pressure Lines

604 Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

Valves and Fittings

605 Valves and fittings intended either for steam pressures above 150 lb. per square inch or temperatures above 425° F. are to be of steel, carbon or low alloy, or other approved material suitable for the working temperature.

Hydraulic Test Pressure

606 All main steam and feed valves and fittings are to be tested by hydraulic pressure to not less than twice the working pressure as defined in E 506 and E 512. Other valves and fittings are to be similarly tested when intended for working pressures above 150 lb. per square inch.

For the testing of boiler mountings *see* J 302 and J 1510.

Steam for Fire Extinguishing in Cargo Holds

607 Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or by drip.

Details of the proposed precautionary measures are to be submitted.

Section 7

BOILER FEED WATER SYSTEMS

Feed Pumps

701 Two separate means of feed are to be provided for all main, auxiliary and donkey boilers which are required for essential services, with the exception of boilers heated exclusively by exhaust gases, where one means of feed will be accepted.

702 Not less than two feed pumping units are to be provided, each of which is to be capable of supplying the requisite amount of feed water to the boilers under full load conditions.

703 A feed pumping unit is to consist of one or more power pumps suitably connected and is to have a total capacity not less than that required in 702.

Where boilers are used exclusively for non-essential services, one of the feed pumping units may be an injector of the required capacity.

704 The pump(s) of one main boiler feed unit may be worked from the main engines, but those of the other unit are to be independently driven.

705 In twin screw steamers in which there is only one independent feed pump, each main engine is to be fitted with a feed pump of adequate capacity. Where both of the feed pumping units are independently driven, each unit is to be connected to deal with the condensate from both engines or from either engine.

706 Independent feed pumps required for feeding the main boilers are to be fitted with automatic regulators for controlling their output.

707 Where main-engine driven feed pumps are fitted and there is only one independent feed pump, a harbour feed pump or an injector is to be fitted to provide the second means of feed to the boilers which are in use when the main engines are not working.

708 Feed pumps are to be provided with valves or cocks so that either pumping unit may continue in operation when the pumps of the other unit are being opened up for overhaul or adjustment.

Sea Suction

709 One of the independent feed pumps is to be provided with an emergency suction to the sea, except in the cases mentioned in 710.

Suctions are also to be provided from this pump to the hotwell or condenser, unless suitable stand-by connections have already been provided for this purpose.

710 In the case of water tube boilers or high pressure cylindrical boilers, the sea suction to a feed pump may be omitted if large reserve feed tanks are provided and an evaporator of adequate capacity is fitted.

Reserve Feed Water

711 All ships fitted with boilers are to be provided with storage space for reserve feed water, the structural and piping arrangements being such that this water cannot be contaminated by oil or oily water.

General Service Pump

712 An auxiliary independent feed pump may be used for general service, provided it is not connected to tanks containing oil fuel or cargo oil or to tanks, cofferdams and bilges containing oily water.

The valves on the suction pipes from the hotwell or condenser and the feed drain tank or filter are to be of non-return type.

Filters

713 Where superheated steam is used in main or auxiliary engines of reciprocating type, filters are to be fitted to provide for the continuous filtration of the boiler feed water.

714 Where a direct contact heater is supplied with exhaust steam from engines of reciprocating type, the feed water from the heater is to be led through the filters required by 713 or through additional filters arranged to provide for continuous filtration.

In lieu of the additional filters, an efficient oil separator may be fitted in the steam supply to the heater.

Cross-references

715 For materials, working pressure and test pressure of feed pipes, *see* E 501 to E 520.

For feed water level regulators for water tube boilers, *see* J 1708.

Section 8

ENGINE COOLING WATER SYSTEMS

Main Supply

801 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

Alternative Supply

802 Provision is also to be made for a separate emergency supply of cooling water from a suitable pump.

Sea Inlets

803 Not less than two independent sea inlets are to be provided for the pumps supplying the salt water cooling system, one for the main pump and one for the stand-by pump.

These inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

Stand-by Fresh Water Pump

804 Where fresh water cooling is employed, a stand-by fresh water pump need not be fitted if there be suitable emergency connections from a salt water system.

Cooling Water Supply to Auxiliaries

805 Where a group of auxiliaries receive their cooling water from a common system instead of each auxiliary having its own cooling water pump, a stand-by cooling water pump is to be provided for this auxiliary system. This pump may be a suitable general service pump.

Strainers

806 Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

Relief Valves

807 Cooling water pumps worked from the main engines are to be provided with relief valves on the pump discharge.

Section 9

LUBRICATING OIL SYSTEMS

Pumps

901 In ships of unrestricted class in which the lubricating oil for the main engines is circulated under pressure and the total power exceeds 400 i.h.p. in the case of steam reciprocating engines and 350 s.h.p. in the case of turbines and internal combustion engines, not less than two lubricating oil pumps are to be fitted and connected ready for immediate use, each pump being of sufficient capacity for normal power.

Similar provision is to be made where separate lubricating oil systems are employed for the operation of reverse reduction gears and oil operated couplings.

Emergency Supply for Main Turbines and Main Turbo-Generators

902 A suitable emergency supply of lubricating oil is to be provided. This may be effected by arranging for an automatic gravity supply of lubricating oil sufficient to maintain adequate lubrication for not less than 3 minutes, and in the case of turbo-generators until the unloaded turbine comes to rest from its maximum rated running speed.

An alarm device is also to be arranged to give audible warning in the event of the failure of, or an appreciable reduction in, the supply of lubricating oil from the pump.

Strainers

903 Where the lubricating oil for the main propelling engines and for the generator engines in electrically propelled ships is circulated under pressure, provision is to be made for efficiently straining the lubricating oil.

904 The strainers or filters are to be capable of being cleaned without stopping the oil supply to the engine.

905 Where strainers are fitted on the discharge side of the lubricating oil pump, a relief valve in close circuit is to be fitted between the pump and the strainer.

Drip Trays

906 In ships built of wood, easily drained metal or metal-lined trays are to be fitted to prevent saturation of the woodwork by leakage from the engine and its filters.

Lubrication of Bearings

907 For details of the requirements relating to the lubrication of bearings of electric generators and motors, *see* L 513 to L 515, also M 228, M 229 and M 1217 to M 1219.

Section 10

PIPING FOR PETROL AND PARAFFIN ENGINES

General

1001 The arrangements are to comply, in general, with the requirements for steamers and ships propelled by heavy oil engines, in so far as these requirements are applicable.

The special requirements detailed in 1002 to 1015 are also to be complied with.

Fuel Tank Filling

1002 Filling stations are to be in the open, having permanent filling pipes to all tanks which are situated within enclosed spaces.

Fuel Tank Air Pipes

1003 All tanks are to be fitted with air pipes led to the open in positions where no danger will be incurred by escaping gas or liquid.

The upper ends of the air pipes are to be fitted with wire gauze diaphragms of incorrodible material, which are to be readily detachable for cleaning.

Fuel Tank Sounding

1004 Wherever practicable, the arrangements for sounding the tanks are to be such that the quantity of fuel in the tanks can be readily ascertained from positions in the vicinity of the filling station.

1005 Gauge glasses are not to be fitted to storage or service tanks containing either petrol or paraffin.

1006 Sounding pipes are to be led to the open deck and are not to terminate in an enclosed space. Striking plates are to be fitted under all sounding pipes, and the sounding rods are to be of non-ferrous material.

Ventilation

1007 The engine room and the compartments in which the fuel tanks are situated are to be efficiently ventilated.

Drainage

1008 All separate fuel tanks are to be provided with metal trays to prevent any possible leakage from the tanks into the bilges. Similar provision is to be made for dealing with leakage from filters and carburettors.

1009 Drip trays are to be so arranged that they can be readily drained by a hand pump or into a portable container through a drain cock.

1010 In ships built of wood, drip trays are to be fitted under the main and auxiliary engines and lubricating oil filters and pumps to prevent saturation of the woodwork by lubricating oil.

Large trays under engines may, however, be replaced by small trays fitted under all parts of the engine from which leakage of lubricating oil is possible.

Suitable arrangements are to be made for collecting the drainage from the crank case when renewing the engine lubricating oil.

1011 Trays under petrol tanks, carburettors or vaporisers and filters are to be covered with wire gauze.

Piping

1012 All petrol or paraffin fuel pipes are to be of annealed seamless copper with flexible bends, and the joints are to be conical, metal to metal.

Where alternative arrangements are desired, details are to be submitted.

The pipes are to be led in positions where they are protected from mechanical injury and, as far as practicable, they are to be exposed to view throughout their length.

1013 The carburettor or vaporiser and the filters are to be provided with shut-off valves or cocks to permit of their being opened up for overhaul without emptying the connecting pipes.

1014 Carburettors and vaporisers are to be so designed that when the engine is stopped the fuel supply is automatically shut off.

If an overflow is provided in the carburettor or vaporiser, a gauze-covered tray, as required by 1008 to 1011, is to be fitted to prevent the fuel from flowing into the bilges.

Strong metallic gauze diaphragms are to be fitted either between the carburettor or vaporiser and the cylinders, or at the air inlets.

1015 The exhaust pipes and silencer are to be efficiently water cooled or lagged to prevent damage by heat, and if the exhaust is led overboard near the

load water line, means are to be provided to prevent water from being syphoned back to the engine. Special arrangements are to be made for drainage if the exhausts are cooled by water spray.

Section 11

PUMPING ARRANGEMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

Hand Pumps

1101 Where auxiliary power is not provided, hand pumps are to be fitted in number and position as may be required for the efficient drainage of the ship.

The pumps are to be capable of being worked from the upper deck or from positions above the load water line which are at all times readily accessible.

The suction lift is not to exceed 24 feet, and is to be well within the capacity of the pump.

1102 The sizes of the hand pumps are not to be less than given in the following table:

Tonnage under Upper Deck	Hand Pumps	
	Diameter of barrel of bucket pump inches	Bore of Suction pipe of bucket pumps and semi-rotary pumps inches
Not exceeding 500 tons ...	4	2
Above 500 tons but not exceeding 1,000 tons ...	$4\frac{1}{2}$	$2\frac{1}{4}$
Above 1,000 tons but not exceeding 2,000 tons ...	5	$2\frac{1}{2}$
Above 2,000 tons	$5\frac{1}{2}$	$2\frac{3}{4}$

Where the ship is closely subdivided into small watertight compartments 2 inches bore suctions will be accepted.

Power Pumps

1103 In ships in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

The pumping arrangements are to be as required for self-propelled ships in so far as these requirements are applicable, duly modified to suit the size and service of the ship.

Details of the pumping arrangements are to be submitted for special consideration.

Fire Extinguishing

1104 Wherever practicable, a power pump or hand pump is to be fitted having a suction from the sea and a discharge to deck for fire extinguishing purposes.

Where oil fuel is used for the generation of power, details of the fire extinguishing appliances are to be submitted.

Section 12

PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 150° F.

General

1201 The following requirements are based on the assumption that the ships are of normal tanker type having the main propelling machinery aft.

Departures from normal type will require special consideration.

Cargo Oil System

1202 A complete system of piping and pumps is to be fitted for dealing with the cargo oil

1203 Cargo pump rooms are to be enclosed by oiltight bulkheads and are to have no direct communication with machinery spaces.

1204 Pumps for the purpose of filling or emptying the cargo oil tanks are to be used exclusively for this purpose, except as provided in 1207. They are not to have any connections to compartments outside the range of cargo oil tanks.

Cargo oil pumps are to be capable of being controlled from outside the pump rooms, as well as at the pumps.

1205 The pumps are to be provided with effective escape valves which are to be in close circuit, i.e., discharging to the suction side of the pumps.

1206 Expansion joints or bends are to be provided where necessary in the cargo pipe lines.

1207 Provision is to be made for the bilge drainage of the cargo pump rooms by pump or bilge ejector suctions. The cargo pumps or cargo stripping pumps may be used for this purpose, provided the bilge suctions are fitted with screw-down non-return valves and, in addition, an isolating valve or cock be fitted on the pump connection to the bilge chest. The pump room bilges of small tankers may be drained by means of a hand pump having a 2 inches bore suction.

Pump room suctions are not to enter machinery spaces.

1208 Pump rooms are to be provided with ready means of access and adequate ventilation.

1209 Ullage plugs or sighting ports are to be provided at each tank to enable the amount of ullage to be ascertained.

Ullage plugs or sighting ports should not be fitted in any enclosed space.

1210 Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

1211 Vapour pipes are to be fitted to the hatches of the cargo oil tanks and connected through shut-off cocks or valves to a vapour line led up the mast to a position above the navigation lights. The outlets from these vapour mains are to be provided with readily renewable wire gauze or safety heads of approved type. If alternative means of dealing with the vapour are desired, details are to be submitted.

Bilge, Ballast, Oil Fuel and other Piping not within the Cargo Oil System

1212 The pumping arrangements in the machinery space and at the forward end of the ship are to comply with the requirements for general cargo ships in so far as they are applicable and with the special requirements detailed in 1213 to 1217.

1213 A separate power pump is to be fitted in a suitable compartment forward of the cargo tanks to deal with bilge drainage, water ballast and oil fuel pumping at the fore end of the ship.

In small tankers, a forward power pump may be dispensed with, provided suitable alternative arrangements are made, details of which are to be submitted.

1214 Where the after deep cofferdam can be filled with water ballast, a ballast pump in the main engine room may be used for emptying the cofferdam, provided the suction be led direct to the pump and not to an engine room pipe system.

1215 Cofferdams are not to have any connections to the cargo oil tanks or cargo oil lines.

Where intended to be dry compartments only, hand pumps or bilge ejector suctions are to be provided.

Cofferdams are to be provided with sounding pipes and with air pipes led to the open. These air pipes are to be fitted with wire gauze diaphragms at their outlets.

1216 Bilge, ballast, oil fuel and other piping connected to the pumps at the ends of the ship are not to pass through the cargo oil tanks or have any connection with these tanks.

Cargo oil pipes are not to pass through ballast or oil fuel tanks or through compartments which are external to the cargo oil system.

1217 The oil fuel bunkering system is to be entirely separate from the cargo oil system.

Steam and Exhaust Piping

1218 Where heating coils are provided in the cargo oil tanks they are to be made and fitted under the usual conditions of survey and testing. (*See* E 508 to E 521 and E 601 to E 607.)

An observation tank is to be provided for the heating coil drains and is to be situated in a well ventilated and well lighted part of the machinery space remote from the boilers.

1219 Steaming out and fire extinguishing connections for cargo oil tanks or cargo oil pipe lines are to be fitted with valves of non-return type and the main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the tanks.

1220 In the cargo pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

Motive Power of Cargo Oil Pumps

1221 Where the cargo oil pumps are not driven by steam, plans of the arrangements for driving the pumps are to be submitted.

1222 Where cargo pumps are driven by shafting which passes through a pump room bulkhead or deck, gastight glands with efficient means of lubrication are to be fitted to the shaft at the pump room plating.

Auxiliary Machinery outside Main Engine Room.

1223 Internal combustion engines are not to be situated within pump rooms, cofferdams or other spaces liable to contain petroleum or other explosive vapours.

(For requirements for electrical equipment within such spaces, *see* M 15.)

18th March, 1954.

Fire Extinguishing Arrangements

1224 The cargo pump rooms are to be provided with a deck operated fire extinguishing system using steam, CO_2 or other suitable medium.

In addition, two portable foam extinguishers are to be provided, one at the pumps and one at the pump room entrance.

Chapter F

FIRE EXTINGUISHING ARRANGEMENTS in machinery spaces and cargo oil pump rooms (including deck fire main).

Section 1

WATER SERVICE AND FIRE PUMPS

Fire Main and its Connections

101 In all ships provision is to be made for pumping water for fire extinguishing service.

102 The fire main is not to be of cast iron, and if made of iron or steel is to be galvanised. It is to be protected from mechanical damage and is not to be led through cargo spaces, if it is practicable to avoid doing so. The wash deck line may be used as a fire main, provided it complies with the requirements of this Section.

103 A relief valve is to be fitted in the engine room on the discharge line from the fire pumps to prevent any excessive pressure arising in the fire main.

The relief valve may be omitted where the maximum pump discharge pressure cannot greatly exceed the jet operating pressure.

104 The sizes of the fire main and of its connections and fittings are to be sufficient to supply in simultaneous operation the fire hoses required by 107. Where the machinery is fitted amidships, the discharge line from the pumps to the fire main is to be led through a change cock (with permanently attached handle) or through two isolating valves so arranged that the hydrants at both ends of the ship may be used either simultaneously or separately.

105 The hose nozzles used for extinguishing fires other than oil fires, are to have a minimum bore of $\frac{1}{2}$ inch.

106 Hydrants are to be provided with shut-off cocks or valves. They are to be arranged so that any part of the ship may be reached by a jet of water about 40 feet in length through a single length of hose, and so that they will be accessible when deck cargo is carried.

Number of Jets of Water

107 The number of jets of water, required to be about 40 feet in length, is to be as follows:—

In ships of less than 1,000 tons gross	...	1 jet
In ships of 1,000 tons gross and over	...	2 jets

Hoses are to be provided so that the required jet can be directed to any part of the ship. Where two jets are required these are to be capable of simultaneous operation.

108 All ships of 1,000 tons gross and over which use oil as fuel, are to be provided with two fire hydrants in the machinery spaces, one port and one starboard, complete with hoses having nozzles suitable for spraying water on oil. In ships less than 1,000 tons gross one such hydrant is to be provided.

The hoses are to be of sufficient lengths to permit an effective spray of water to reach any part of the engine or boiler rooms which contain oil fuel tanks or appliances.

Fire Pumps

109 In ships less than 150 tons gross, one power pump is to be available for fire extinguishing service. If the ship has a restricted class for harbour or river service a suitable hand pump may be substituted for the power pump.

110 In ships of 150 tons gross and over, but less than 1,000 tons gross, not less than two power pumps are to be provided, one of which is to be an independent pump.

111 In ships of 1,000 tons gross and over, not less than two independent power pumps are to be provided.

112 Fire pumps may be engine room general service pumps or ballast pumps, provided they are arranged to prevent oil being discharged accidentally into the fire extinguishing system.

113 Each fire pump is to be capable of maintaining, at the hose nozzles, the 40 foot jets of water required by 107.

114 If in ships of 1,000 tons gross and over, which burn oil as fuel, a fire in any one compartment could put all the fire pumps out of action, alternative means for extinguishing the fire are to be provided either by emergency fire pumps driven by compression ignition oil engines, or by other approved fire extinguishing system.

FIRE EXTINGUISHING EQUIPMENT IN MACHINERY SPACES OF OIL BURNING STEAMSHIPS AND MOTORSHIPS

Section 2

General Requirements

201 The machinery spaces are to be provided with the fire hydrants and hoses required by F 108.

202 Provision is to be made for stopping from positions outside the machinery spaces, ventilating fans for these compartments, also other fans or blowers situated within the compartments, and for closing as far as practicable all openings to the machinery spaces.

The engine room skylights are to be capable of being shut from deck or from a safe position outside the machinery space.

Cross-references

203 For other precautionary arrangements relating to oil leakage and outbreaks of fire see:—

D 2024–2025, D 2027, and E 309, E 314–318, E 326–329, E 333–339, E 403–405, E 407, E 413–414.

Section 3

Oil Burning Steamships

301 There is to be provided at each firing platform:—

(*a*) A bin containing not less than 10 cubic feet of sand, sawdust impregnated with soda, or other dry material suitable for extinguishing oil fires. Scoops are to be provided at each bin.

(*b*) Not less than two portable fire extinguishers.

302 In addition, a froth extinguisher of 10 gallons capacity, or equivalent, is to be provided in each boiler room in which the number of burners exceeds four. Where the number of burners in a boiler room is four or less, the 10 gallon extinguisher may be replaced by one portable fire extinguisher of 2 gallons capacity, or its equivalent, for each burner.

The number and position of the portable extinguishers are to be such that not less than two extinguishers are situated within any compartment containing settling tanks or the whole or part of the oil fuel installation.

303 In boiler rooms and in any space in which oil fuel units or settling tanks are situated, a fire extinguishing apparatus is to be provided which can be controlled from outside these compartments, at positions which are easily accessible and which would not readily be cut off by an outbreak of fire in any of the above-mentioned compartments. If the engine and boiler rooms are not entirely separate and oil fuel can drain from one compartment to the other, these spaces shall be considered as one compartment.

The apparatus is to be capable of discharging rapidly, through a permanent piping system, a fire extinguishing medium which is to be either froth, CO_2 or steam.

Froth Apparatus

304 The froth apparatus is to be capable of discharging froth to a depth of 6 inches over the largest area on which oil fuel is liable to spread in the event of a leakage of oil fuel.

Where the boilers are situated in an upper part of the machinery space, the above requirement applies also to the flat on which the boilers are situated.

305 Where the upper parts of the machinery spaces contain oil fuel tanks and appliances, additional fire protection is to be provided by fitting a froth extinguisher of 10 gallons capacity, or a CO_2 extinguisher of 35 lb. capacity, having a hose on reel capable of reaching any surface of the upper machinery space on which escaping oil would be liable to fall.

CO_2 Apparatus

306 The CO_2 fire extinguishing apparatus is to be capable of discharging gas in sufficient quantity to give a minimum volume of free CO_2 equal to 30 per cent of the gross volume of the largest space measured to the top of the boilers. The volume of the gas is to be taken as 9 cubic feet per pound of liquified CO_2.

If the upper parts of the machinery spaces contain oil fuel tanks and appliances, it will be necessary to supply, in addition, the 10 gallon froth extinguisher or the 35 lb. CO_2 extinguisher required by 305.

307 If the CO_2 is supplied in sufficient quantity to give a minimum volume of free CO_2 equal to 30 per cent of the gross volume of the largest space measured to the top of the casing of the compartment and the gas is discharged into the upper part of the space as well as into the lower part, the 10 gallon froth extinguisher or the 35 lb. CO_2 extinguisher required by 306 need not be provided.

308 Where CO_2 is used as the fire extinguishing medium in cargo holds as well as in machinery spaces, the total quantity of CO_2 need not exceed that required for the largest compartment protected in this way, whether cargo or machinery space.

309 The CO_2 fire extinguishing system is to be provided with an automatic audible alarm to operate when the CO_2 is about to be injected into the machinery space

or other working space. The arrangement of controls for the CO_2 apparatus is to be such that the apparatus may be operated only at the control station(s).

Steam Apparatus

310 Where steam is used as the fire extinguishing medium, it is to be led to pipes perforated for the emission of steam into the lower parts of the compartments. Where the boilers are situated in an upper part of the machinery space, the above requirement applies also to the flat on which the boilers are situated.

Steam for the apparatus is to be available in sufficient quantity from all boilers.

The perforated pipes are to be fitted not less than 6 inches above the tank top and bilges to avoid immersion in an accumulation of bilge water. If the pipes are of steel they are to be galvanised internally and externally. They are to be arranged to be self-draining. If the steam for the fire extinguishing system is obtained exclusively from water tube boiler(s), a 30 gallon froth extinguisher or a 100 lb. CO_2 extinguisher is also to be provided.

Steam used for fire extinguishing purposes is not to be obtained from a supply of superheated steam.

Steamships having Auxiliary Oil Engines

311 In oil burning steamships where oil engines are installed as the main source of auxiliary power, two portable extinguishers additional to the above requirements are to be provided ; otherwise, no additional equipment will be required.

In coal burning steamships fitted with auxiliary oil engines the fire extinguishing arrangements are to be submitted for consideration.

Section 4

Motorships not fitted with Boilers

401 The following extinguishers are to be provided in the machinery space:—

B.H.P. of Main Engines in one Engine Room	Number of Extinguishers	
	Portable	10 gallon capacity or equivalent
Not exceeding 500	2	—
501 to 1,000 inclusive	2	1
1,001 to 2,000 ,, ...	3	2
2,001 to 3,000 ,, ...	4	2
3,001 to 4,000 ,, ...	5	2
Exceeding 4,000	6	2

The number and position of the extinguishers are, however, to be such that not less than two extinguishers are to be provided in each machinery space containing oil fuel tanks or appliances.

402 In motorships having more than one engine room, the requirements of 401 are to be applied to each engine room.

If a separate engine room is provided for auxiliary oil engines, the b.h.p. is to be taken as the total power of these engines.

Motorships Fitted with Oil Fired Boilers

403 In addition to the requirements of 401 and 402, the requirements of Section 3 are to be complied with so far as they are applicable, but the total number of 10 gallon extinguishers need not exceed two in any one machinery space.

In motorships in which the oil fired boiler installation consists of a vertical boiler situated in the open engine room, the externally controlled fire extinguishing apparatus required by 303, may be replaced by a froth extinguisher capable of providing not less than 6 inches of froth over the entire area of the oiltight tray or flat situated under the boiler. This tray is to be of adequate dimensions to ensure the collection of any escaping oil in the vicinity of the boiler.

Section 5

FIRE EXTINGUISHERS

501 The extinguishers required for use in the machinery spaces of ships burning oil as fuel are to be of a type discharging froth, CO_2 or other approved medium suitable for extinguishing oil fires.

Portable extinguishers are to have a minimum capacity of 2 gallons or equivalent and a maximum capacity of 3 gallons or equivalent.

The extinguisher capacities mentioned in these Rules refer to the quantity of fluid contained in the extinguishers.

502 Portable extinguishers are to be fitted in readily accessible positions and a notice plate is to be provided stating that on no account are discharged extinguishers to be replaced in their holders until they have been replenished.

One extinguisher is to be fitted in the vicinity of the entrance door to the space in which it is intended to be used.

503 A spare charge is to be provided for each portable fire extinguisher which can be readily re-charged on board. If this cannot be done, duplicate extinguishers are to be provided.

504 The makers of portable and fixed fire extinguishing appliances are to furnish a certificate stating the nature and quantity of the fire extinguishing medium. In the case of fixed froth or gas fire extinguishing systems the makers are to state whether the quantity supplied is adequate to give the required depth of froth or gas concentration.

If considered necessary, the Committee may require the makers to produce evidence from a recognised independent testing authority regarding the suitability of their appliances.

8th January, 1953.

Acceptable Equivalents

505 30 gal. froth extinguisher–100 lb. CO_2 extinguisher
10 gal. froth ,, – 35 lb. CO_2 ,,
Portable froth ,, – 10 lb. CO_2 ,,

Cross-reference

506 For Fire Extinguishing requirements for pump rooms of Petroleum Tankers *see* E 1224.

Section 6

EQUIVALENT ARRANGEMENTS

601 Arrangements and appliances which differ from those mentioned in the foregoing requirements may be accepted, provided full details are submitted, as early as practicable, for the consideration of the Committee and are found to be equivalent to the Society's requirements.

Chapter G

CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

Section 1

101 The materials used in the construction of the machinery, boilers and pressure vessels are to comply with the requirements of Chapter P. Materials, for which provision is not made in Chapter P, may be accepted after compliance with such tests as may be imposed, under specifications to be approved before the materials are ordered and construction is commenced.

The machinery, boilers and pressure vessels are to be inspected throughout, the boilers and pressure vessels tested by hydraulic pressure, and the machinery tested under full power working conditions by the Society's Engineer Surveyors, who will furnish a report to the Committee. If found satisfactory, the Committee will thereupon grant a certificate, and insert in the Register Book the appropriate class notation, as set forth in Chapter B, indicating that the machinery, boilers and pressure vessels are certified to have been in good order and safe working condition on that date.

102 In cases of machinery which has been built under Special Survey, the distinguishing mark ✠ will be inserted before the appropriate class notation, as set forth in Chapter B.

103 In ships built under Special Survey, the following items of machinery are also to be constructed under Special Survey :—

The main and auxiliary engines and boilers, superheaters, economisers (including press boilers and similar apparatus for floating whale-oil factories), steering engines, air receivers, air compressors, scavenge blowers and superchargers, oil fuel burning units, feed pumps, circulating and cooling water pumps, fire and bilge pumps, air pumps, ballast and oil fuel transfer pumps, water extraction pumps, lubricating oil pumps, fuel valve cooling pumps for heavy oil engines, forced and induced draught fans, evaporators, distiller units, feed water heaters and pressure filters where the foregoing are intended for essential services and domestic boilers intended for working pressures exceeding 50 lb. per square inch or having heating surfaces greater than 50 square feet.

104 In order to facilitate the inspection, plans in triplicate of the following items, together with the necessary particulars of the machinery, including the maximum power and the revolutions per minute, are to be submitted for consideration before the work is commenced :—

Boilers, superheaters and economisers.
Air receivers.
Crank, thrust, intermediate and screw shafting.
Clutch and reversing gear.
Reduction gearing. (*See also* H 503.)
Propeller (including spare propeller if supplied).

NOTES.—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

For Plans of Pumping and Piping required to be submitted, *see* E 101.

105 Where it is proposed to depart from the requirements of the Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

106 Any novelty in the construction of the machinery, boilers or pressure vessels is to be reported to the Committee.

107 The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions; any defects, etc., are to be pointed out as early as possible.

108 The Surveyors may also, if requested, compare the work as it progresses with the requirements of the specification agreed upon by the parties concerned, and certify to the conditions thereof, as far as can be seen, being satisfactorily complied with.

109 The machinery and boilers are to be securely fixed to the ship's structure to the satisfaction of the Surveyor. The bed plates, gear cases, thrust blocks and boiler fastenings are to be of robust construction.

110 For conditions relating to the survey during construction of Electric Propelling Machinery, Electrical Equipment and Refrigerating Machinery and Appliances, *see* L 1 and L 2, M 1 and N 1 respectively.

18th March, 1954

Chapter H

STEAM ENGINES, INTERNAL COMBUSTION ENGINES, REDUCTION GEARING AND AUXILIARY MACHINERY

Section 1

GENERAL REQUIREMENTS FOR SHAFTING

Materials for Shafts

101 Shafts may be forged from ingot steel, wrought iron bars piled, or scrap wrought iron, and they may be wrought by hammer, press, or where in straight lengths, by rolling mill.

102 If scrap is used it must be of uniform quality and be thoroughly cleansed. A mixture of iron and steel scrap is not permitted in any case.

103 Where ingot steel is used for shafts it is to comply generally with the requirements of P 10.

104 Where ingot steel shafts are made by rolling and the couplings are formed from the shafts by upsetting, the test pieces may be cut from the outer edges of the couplings.

Materials for Couplings

105 Couplings of wrought iron shafts may be welded to the body of the shaft, but those of ingot steel shafts are to be forged from the solid or by upsetting the ends by hydraulic pressure.

106 Couplings, where separate from the shaft, may be forged from ingot steel or wrought iron ; or they may be steel castings.

Materials for Crank Shaft Webs

107 Webs of built crank shafts may be forged or rolled from ingot steel or wrought iron ; or they may be steel castings.

108 The material of rolled or forged steel webs is to comply with the requirements of P 10. The test pieces are to be taken crosswise from the webs as rolled or forged.

109 The material of cast steel webs is to comply with the requirements of P 9.

Inspection

110 All shafts are to be turned all over and are to be examined when rough turned and when finished.

Alignment Gauges

111 All main and auxiliary heavy oil engines exceeding 300 b.h.p. and all main steam reciprocating engines are to be provided with alignment gauges which may be either a bridge gauge or a micrometer clock gauge for use between the crank webs.

Only one micrometer clock gauge, suitable for all the engines, need be supplied for each ship.

Main and auxiliary steam turbines are to be provided with gauges of an approved type for testing the alignment of the rotor, pinion and gear wheel shafts.

Wear down gauges and turbine alignment gauges should be adjusted in the presence of the Surveyor.

Section 2

STEAM RECIPROCATING ENGINES

Dimensions of Shafts

201 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28-32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting. Where engines have cylinders of uniform diameter and in other types of engines where experience indicates that serious critical speeds might occur within or near the range of working speeds, calculations of the torsional vibration characteristics, including 1-node natural frequency tables, for the complete shafting system, are to be submitted for consideration together with plans of all shafting and of the propeller.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

These calculations are not required to be submitted for engines other than these special cases ; they may, however, be submitted voluntarily, if desired.

The Committee will accept intermediate shafts with a diameter 5 per cent less than required by the Rule formulæ, in all cases where calculations confirm that the shafting systems are free from excessive vibration stress or would be satisfactory with a barred speed range.

This 5 per cent reduction in diameter will be limited to the intermediate shafts only and will not be applicable to the sizes of couplings and their bolts.

Where serious critical speeds are found by calculation to occur within the range of working speeds, the Committee may require torsiograph records to be taken from the machinery, for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

202 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Intermediate Shaft

203 The diameter of the intermediate shaft is not to be less than that given by the following formula :—

$$\text{Diameter of intermediate shaft, in inches} = \sqrt[3]{\frac{D^2 \times S \times WP}{C\left(\frac{D^2}{H^2} + 2\right)}}$$

where WP=working pressure at the boiler outlet, in lb. per square inch.

NOTE.—The working pressure at the boiler outlet is the pressure as controlled by boiler or superheater safety valves and as defined in E 512.

D = diameter of the low pressure cylinder, in inches, or the equivalent diameter where two or more low pressure cylinders are fitted,

H = diameter of the high pressure cylinder, in inches,

S = length of stroke, in inches.

C is a coefficient given in the following Table :—

Compound, triple or quadruple expansion reciprocating engines	Values of C
2 cranks at 90°	1900
2 cranks at 180°	1350
3 cranks at 120°	2150
4 cranks balanced	2150
4 cranks at 90°	2100

Note : The rule diameter of the intermediate shaft may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

For the diameter of the intermediate shafting of steam reciprocating engines combined with exhaust steam turbines, *see* H 304.

Crank Shaft

204 The diameter of the crank shaft is not to be less than 1·05 times that required for the intermediate shaft as determined by 203.

Crank Webs of Solid Forged Shafts

205 In solid forged shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter required for the crank shaft or, if these proportions are departed from, the webs are to be of equivalent strength.

Crank Webs of Built Shafts

206 The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ :—

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in inches or millimetres,

t = thickness of metal around the eyeholes, measured radially, in inches or millimetres,

d = diameter required for the crank shaft, in inches or millimetres.

If these proportions are departed from, the webs are to be of equivalent strength.

207 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

208 Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch, and the shrinkage allowance is to be between $\frac{1}{350}$ and $\frac{1}{700}$ of the diameter of the shaft.

Thrust Shaft

209 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·05 times that required for the intermediate shaft as determined by 203; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

210 The diameter of the tube shaft which passes through the stern tube but does not carry the propeller, is not to be less than 1·05 times that required for the intermediate shaft as determined by 203, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times the diameter required for the intermediate shaft as determined by 203.

Screw Shaft

211 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula :—

$$\text{Diameter of screw shaft, in inches} = d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches, as determined by 203,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,
100 when the shaft is not fitted with a continuous liner.

212 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

213 For screw shafts of ships intended to have the notation " Strengthened for navigation in ice," *see* 227.

Hollow Shafts

214 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze Liners on Shafts

215 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula :—

$$t = \frac{d + 9{\cdot}25}{32}$$

where t = thickness of the liner, in inches,

d = diameter required for the screw or tube shaft under the liner, in inches.

216 The thickness of a continuous liner between the bushes is not to be less than ·75t.

217 Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

218 Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

219 If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

220 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern bush

221 The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by rule for the screw shaft under the liner.

Coupling Bolts

222 With coupling bolts of ordinary mild steel having a minimum tensile strength of 28 tons per square inch, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts,}\\ \text{in inches or millimetres}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d = diameter, in inches or millimetres, required for the intermediate shaft, as determined by H 203, H 303 or H 304, whichever is applicable,

n = number of bolts in the coupling,

r = radius of the pitch circle of the bolts, in inches or millimetres.

Couplings

223 The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 222. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft as determined by H 203, H 303 or H 304, whichever is applicable.

224 The fillet radii at the base of flanges should not be less than ·125 of the diameter of the shaft.

225 Where couplings are separate from the shafts provision is to be made to resist the astern pull.

Bronze propellers

226 Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 14.

Ships having the notation "Strengthened for navigation in ice"

Screw Shaft

227 The diameter of the screw shaft is to be increased 5 per cent above that determined by 211 and 212.

Propeller

228 The propeller or propeller blades are to be made of cast steel or other approved material. The material is to comply with the requirements of P 9 or P 14.

Section 3

TURBINES AND PROPELLING MOTORS

Dimensions of Shafts

301 The intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28-32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of torsional vibration arising in the shafting and gearing.

With turbine engines situated aft, calculations of the torsional vibration characteristics for the dynamic system formed by the turbine, gearing, line shafting and propeller are to be submitted for consideration together with plans of all shafting and propeller and details of power developed by individual turbines throughout the speed range.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the vibration torques, as evidenced by tooth separation and gear hammer, are considered to be excessive.

302 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Steam Turbines and Electric Propelling Motors

303 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in inches}\end{array}\right\} = 3{\cdot}8\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum designed shaft horse power,

R = revolutions per minute at maximum power.

Steam Reciprocating Engines combined with Exhaust Steam Turbines

304 Where steam reciprocating engines are combined with exhaust steam turbines by means of mechanical gearing the diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in inches}\end{array}\right\} = 3{\cdot}8\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum combined shaft horse power at the intermediate shaft,

R = revolutions per minute at maximum power.

NOTE: The s.h.p. of a reciprocating engine may be taken as 90 per cent of the indicated horse power.

The diameter of the straight shafting should in no case be less than required for the reciprocating engine when working without a turbine.

The sizes of thrust, tube and screw shafts are to be determined by H 209, H 210, H 211 and H 212 or by 307, 308, 309 and 310, whichever are the greater.

NOTE: The rule diameter of the intermediate shaft as determined by 303 or 304 may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

Wheel Shafts of Geared Steam Turbines

305 Where there are two pinions geared into the wheel, opposite, or nearly opposite, to one another, the diameter of the wheel shaft is not to be less than 1·1 times that required for the intermediate shaft.

306 Where there is only one pinion geared into the wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the wheel and the adjacent journals is not to be less than 1·16 times that required for the intermediate shaft. Abaft the journals the shaft may be gradually tapered down to the diameter required for the intermediate shaft.

Thrust Shaft

307 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·1 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

308 The diameter of the tube shaft which passes through the stern tube but does not carry the propeller is not to be less than 1·1 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·13 times that required for the intermediate shaft.

Screw Shaft

309 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in inches} = 1{\cdot}05\ d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,
100 when the shaft is not fitted with a continuous liner.

310 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

Cross-references

311 For requirements for hollow shafts, shaft liners, stern bush, coupling bolts, couplings and propellers *see* H 214 to H 226.

Ships having the notation "Strengthened for navigation in ice"

Screw Shaft

312 The diameter of the screw shaft is to be increased 5 per cent above that determined by 309 and 310.

Propeller

313 The propeller or propeller blades are to be made of cast steel or other approved material. The material is to comply with the requirements of P 9 or P 14.

Section 4

GENERAL REQUIREMENTS FOR STEAM ENGINES

Steam Reciprocating Engines

401 Explosion relief devices are to be fitted to the crank cases of enclosed forced lubricated steam reciprocating engines where the crank case volume is 20 cubic feet and over. The arrangement and sizes of the relief devices are to comply with the requirements of H 812 to H 815 where applicable.

402 Auxiliary steam engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on.

Steam Turbines

403 In single screw ships fitted with steam turbines the arrangements are to be such that steam can be led direct to the L.P. turbine and either the H.P. or I.P. turbine can exhaust direct to the condenser.

404 Sufficient astern power is to be provided to maintain adequate control of the ship in all normal circumstances and for this purpose two astern turbines are to be provided except in single screw ships, where one astern turbine may be fitted.

405 One emergency overspeed governor shall be provided for the ahead turbine or turbines driving each propeller shaft either direct or through gearing so as to shut off the steam automatically, and prevent the maximum designed speed being exceeded by more than 15 per cent.

Hand trip gear shall also be provided for shutting off the steam.

406 Arrangements are to be made for the steam to the ahead turbines to be automatically shut off in the event of the failure of the lubricating oil system.

407 Auxiliary steam turbines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on.

Hydraulic Tests : Steam Reciprocating Engines

408 The cylinders of steam reciprocating engines are to be tested by hydraulic pressure as follows :—

COMPOUND EXPANSION ENGINES :

H.P. Cylinder	WP × 1·5
L.P. Cylinder	30 lb. per square inch.

TRIPLE EXPANSION ENGINES :

H.P. Cylinder	WP × 1·5
I.P. Cylinder	WP × ·5
L.P. Cylinder	30 lb. per square inch.

QUADRUPLE EXPANSION ENGINES :

H.P. Cylinder	WP × 1·5
First I.P. Cylinder ...	WP × ·6
Second I.P. Cylinder ...	WP × ·4
L.P. Cylinder	30 lb. per square inch.

Where WP is the boiler working pressure in lb. per square inch.

Hydraulic Tests : Steam Turbines

409 The nozzle boxes of impulse steam turbines are to be tested by hydraulic pressure to 1·5 times the boiler working pressure.

The steam casings of all turbines are to be tested by hydraulic pressure to 1·5 times the working pressure in the casing or to 30 lb. per square inch, whichever is the greater.

Cross-references

410 Steam engines and turbines intended for driving electric generators are to comply with the requirements of L 3 and M 2 where applicable.

411 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

412 The feed, bilge and general service pumps, steam and other pipes, cocks, sea connections, pumping arrangements and forced lubrication, are to comply with the requirements of Chapter E.

Section 5

REDUCTION GEARING FOR MAIN PROPELLING MACHINERY

General

501 The following requirements are applicable to all cases of reduction gearing for propelling purposes where more than 500 s.h.p. is transmitted to the intermediate shaft.

Materials

502 The materials used for pinions, pinion sleeves and gear wheel rims are to comply with the requirements of P 12.

Submission of Plans

503 Plans of gearing are to be submitted for approval together with the following particulars :—

Shaft horse power and revolutions for each pinion,
Number of teeth in each gear,
Pitch circle diameters,
Helix angle,
Normal pitch of teeth,
Addendum,
Dedendum,
Type of tooth profile,
Face widths,
Pressure angle of teeth (normal or transverse).

In addition, arrangement plans are to be submitted for approval.

Welded Construction

504 In the case of welded construction, full details of the welding and welding procedure are to be indicated. Gear wheels and gear cases of welded construction are to be suitably stress-relieved, particulars of which are to be submitted.

Gear Loads

505 Gear loads for maximum designed shaft horse power are not to exceed those given by the following formula :—

$$P = K \times d \times \frac{R}{R + 1}$$

where P = load in lb. per inch of overall face width, without deduction for chamfering and tapering of tooth ends,

K = 80, except in the case of double reduction gears having the secondary pinion solid with the primary wheel, where K is to be taken as 67 for secondary gears only,

d = pitch circle diameter of the pinion, in inches,

R = the gear ratio, pinion speed/gear wheel speed.

In cases where it is desired to use a higher value of P than that permitted by the foregoing formula, the Committee will be prepared to give consideration to the circumstances of any special case.

Primary Pinion Bearings

506 A centre bearing is to be provided between the right and left-hand helices, where the total axial length in inches over the gear face and gap is greater than

$$d \times (3{\cdot}5 - {\cdot}25\sqrt{d})$$

where d = pitch circle diameter of the pinion, in inches.

Dressing of the Ends of the Teeth

507 The ends of the teeth are to be cut back at an angle of 45 to 60 degrees to the pitch line and, in the case of pinions, are to be tapered on each tooth flank to an extent of at least ·03 inch to nothing at a distance of $\frac{3}{8}$ inch measured parallel to the chamfered tooth end.

Balance of Gear Pinions and Wheels

508 All primary pinions over 12 inches in diameter, complete with half claw couplings where fitted, are to be balanced dynamically.

All primary wheels, including those with secondary pinions, also main wheels, are to be balanced statically.

Alignment and Bedding of Gears

509 The alignments of all wheel and pinion shafts, primary pinion drives from the turbines, main wheel and line shafting, also the bedding of the gears, are to be to the satisfaction of the Surveyors.

Section 6

REDUCTION GEARING FOR AUXILIARY ELECTRICAL GENERATING MACHINERY

General

601 The following requirements are applicable to all cases of reduction gearing used in the generation of electric power for essential auxiliary services.

Materials

602 The requirements of P 12 are to be complied with, but where the gearing transmits less than 150 s.h.p. the material tests need not be witnessed by the Surveyors.

Submission of Plans

603 The requirements of H 503 are to be complied with where the gearing transmits 150 s.h.p. or over.

Welded Construction

604 The requirements of H 504 are to be complied with.

Gear Loads

605 Gear loads are not to exceed those given by the following formula :—

$$P = K \times d \times \frac{R}{R+1}$$

where P = load in lb. per inch of overall face width, without deduction for chamfering and tapering of tooth ends,

K = 90 at normal full load rating and 112·5 based on 25 per cent overload,

d = pitch circle diameter of the pinion, in inches,

R = the gear ratio, pinion speed/gear wheel speed.

Primary Pinion Bearings

606 The requirements of H 506 are to be complied with.

Dressing of the Ends of the Teeth

607 The ends of the teeth are to be cut back at an angle of 45 to 60 degrees to the pitch line, and in the case of pinions, may be tapered on each tooth flank to an extent of ·02 inch to nothing at a distance of $\frac{1}{4}$ inch measured parallel to the chamfered tooth end.

Balance of Gear Wheels

608 Gear wheels are to be either statically or dynamically balanced.

Alignment and Bedding of Gears

609 The alignments of wheel and pinion shafts, also the bedding of the gears, are to be to the satisfaction of the Surveyors.

Section 7

HEAVY OIL ENGINES

Dimensions of Shafts

701 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28-32 tons per square inch are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of dangerous torsional vibration stresses arising in the shafting.

Calculations of torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing, generators or other components,

where these are interposed, are to be submitted for consideration, together with plans of all shafting and of the propeller. These calculations should include :—

(*a*) Natural frequency tables for one and two noded modes of vibration, also higher modes if necessary.

(*b*) Vector summation for all orders of vibration occurring at speeds up to 20 per cent above the service speed.

(*c*) Particulars of the firing order in the case of four cycle engines.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where the Engine Builders' estimate of vibration stresses is based on torsiograph records from previous installations, particulars of the estimated stresses are to be submitted in cases where the stresses approach the limits indicated in the Society's Guidance Notes.

The torsional vibration characteristics of heavy oil engines driving auxiliary machinery used for essential services at sea are to be such as to ensure that the operating speed ranges are clear of significant critical speeds. Where the power developed by these auxiliary engines is 150 b.h.p. or 100 kW and over, torsional vibration calculations are to be submitted for approval as required for propelling machinery.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

The submission of torsional vibration characteristics will not be required for ships classed for smooth water service when fitted with engines having powers less than 100 b.h.p.

702 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Crank Shaft

703 The diameter of the crank shaft is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of crank shaft,}\\ \text{in inches or millimetres}\end{array}\right\} = \sqrt[3]{\frac{D^2 \times (PL + CpS)}{10{,}000}}$$

where D = diameter of cylinder, in inches or millimetres,

S = length of stroke, in inches or millimetres,

L = span of bearings adjacent to a crank measured from inner edge to inner edge, in inches or millimetres,

P = maximum pressure in lb. per square inch,

p = mean indicated pressure in lb. per square inch,

C is a coefficient found from Table I, which follows after H 1001.

Crank Webs of Solid Forged Shafts

704 In solid forged shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter required for the crank shaft, or, if these proportions are departed from, the webs are to be of equivalent strength.

Crank Webs of Built Shafts

705 The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ: —

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in inches or millimetres,

t = thickness of metal around the eyeholes, measured radially, in inches or millimetres,

d = diameter required for the crank shaft, in inches or millimetres.

If these proportions are departed from, the webs are to be of equivalent strength.

706 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

707 Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch and the shrinkage allowance is to be between $\frac{1}{850}$ and $\frac{1}{700}$ of the diameter of the shaft.

Intermediate Shaft

708 The diameter of the intermediate shaft is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in inches}\end{array}\right\} = C \sqrt[3]{\frac{BHP}{R}}$$

where BHP = maximum designed brake horse power.

R = revolutions per minute, at maximum power,

C is a coefficient found from Table II or III for single acting engines or from Table IV for double acting engines, by interpolation from the values found for A and the piston speeds.

Note: The Rule diameter of the intermediate shaft may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

In using Tables II, III and IV the appropriate value of A is found thus :—

$$A = \frac{D^2 \times S}{(Wd^2 + 6{\cdot}24\ wr^2) \times R^2}$$

where D = diameter of cylinder, in inches,

S = length of stroke, in inches,

R = revolutions per minute, at maximum power,

W = total weight of flywheel, in tons,

d = diameter of flywheel, in feet,

w = total weight of balance weights, in tons,

r = radius of gyration of balance weights, in feet.

Flywheel Shaft

709 The diameter of the flywheel shaft is to be not less than that required for the crank shaft.

Thrust Shaft

710 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·1 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

711 The diameter of the tube shaft which passes through the stern tube but does not carry the propeller, is not to be less than 1·1 times that required for the intermediate shaft, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·13 times that required for the intermediate shaft.

Screw Shaft

712 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula :—

$$\text{Diameter of screw shaft, in inches} = 1{\cdot}05d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,
100 when the shaft is not fitted with a continuous liner.

713 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

714 For screw shafts of ships intended to have the notation "Strengthened for navigation in ice" *see* 728.

Hollow Shafts

715 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze Liners on Shafts

716 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula :—

$$t = \frac{d + 9{\cdot}25}{32}$$

where t = thickness of the liner, in inches,

d = diameter required for the screw or tube shaft under the liner, in inches.

717 The thickness of a continuous liner between the bushes is not to be less than ·75 t.

718 Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

719 Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

720 If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

721 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern Bush

722 The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by rule for the screw shaft under the liner.

Coupling Bolts

723 With coupling bolts of ordinary mild steel having a minimum tensile strength of 28 tons per square inch, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula :—

$$\left.\begin{array}{l}\text{Diameter of the coupling bolts,}\\ \text{in inches or millimetres.}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d = diameter, in inches or millimetres, required by 708 for the intermediate shaft in case of thrust, intermediate and screw shafts, and is ·95 of the diameter required by 703 for the crank shaft in the case of crank and flywheel shafts,

n = number of bolts in the coupling,

r = radius of the pitch circle of the bolts, in inches or millimetres.

Couplings

724 The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 723. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft, as determined by 708.

725 The fillet radii at the base of flanges should not be less than ·125 of the diameter of the shaft.

726 Where couplings are separate from the shafts provision is to be made to resist the astern pull.

Bronze Propellers

727 Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 14.

Ships having the notation "Strengthened for navigation in ice"

Screw Shafts

728 The diameter of the screw shaft is to be increased 5 per cent above that determined by 712 and 713.

Propeller

729 The propeller or propeller blades are to be made of cast steel or other approved material. The material is to comply with the requirements of P 9 or P 14.

Section 8

GENERAL REQUIREMENTS FOR HEAVY OIL ENGINES AND STARTING AIR COMPRESSORS

General

801 Special attention is to be given to the ventilation of the engine room.

802 Cylinder relief valves are to be fitted to engines of 8 inches bore or over. The valves are to be loaded to not more than 40 per cent above the designed maximum pressure and are to discharge where no damage can occur.

803 Where scavenging is effected by a single independent scavenging blower alternative or duplicate means for driving the blower are to be provided ready for use.

804 Scavenge manifolds of main engines are to be provided with explosion relief valves.

805 The exhaust pipes and silencer are to be water cooled or efficiently lagged to prevent damage by heat; if the exhaust is led overboard near the water-line, means are to be provided to prevent water from being syphoned back to the engine.

806 An efficient governor is to be fitted to each main engine to prevent excessive racing.

807 Auxilary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on.

Starting Arrangements

808 Equipment for starting the main and auxiliary engines is to be provided so that the necessary initial charge of starting air or initial electric power can be developed on

board ship without external aid. If for this purpose an emergency air compressor or electric generator is required, these units are to be power driven by hand starting oil engine or steam engine, except in the case of small installations where a hand operated compressor of approved capacity may be accepted.

809 Two or more starting and manœuvring air compressors are to be fitted of sufficient total capacity for the requirements of the main engines. Each compressor is to be fitted with a safety valve so proportioned and adjusted that the accumulation with the outlet valve closed will not exceed 10 per cent of the maximum working pressure. The casings of the cooling water spaces are to be fitted with a safety valve or bursting disc so that ample relief will be provided in the event of the bursting of an air cooler tube.

810 Where the main engines are arranged for air starting the total air receiver capacity is to be sufficient to provide, without replenishment, not less than twelve consecutive starts of each main engine if of the reversible type and not less than six consecutive starts if of the non-reversible type. For scantlings and fittings of air receivers *see* J 24.

811 Where main engines are fitted with electric starters, the batteries are to have sufficient capacity without recharging to provide the number of starts of the main engines as required by 810. In other respects batteries are to comply with the requirements of L 10.

Crank Case Safety Fittings

812 Crank cases are to be provided with lightweight spring-loaded valves or other quick-acting and self-closing devices to relieve the crank case of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. At least one of these valves should be fitted to each cylinder crank case. In the case of small auxiliary engines, where crank case and doors are inherently strong, one relief valve may be considered sufficient. In the case of small engines of less than 6 inches bore, relief valves may be omitted. The discharge from the valves is to be shielded where necessary to minimise the possibility of danger and damage arising from the emission of flame.

813 The minimum sizes of relief valves are to be determined on a basis of 1 square inch of valve area per 5 cubic feet of crank case volume for engines with a crank case volume per cylinder of 100 cubic feet and over and on a basis of 1 square inch per 10 cubic feet, plus 10 square inches, for smaller engines. No valve is to be less than 3 inches diameter or equivalent area.

814 Crank cases are to be of robust construction and crank case doors are to be securely fastened so that they will not be readily displaced by an explosion.

815 Lubricating oil drain pipes from engine sump to drain tank are to be submerged at their outlet ends. Where two or more engines are installed, vent pipes, if fitted, and lubricating oil drain pipes are to be independent to avoid inter-communication between crank cases.

816 Crank cases of large starting air compressors are to be fitted with explosion relief devices as required for auxiliary engines in cases where the crank case volume is 20 cubic feet and over.

Crank Case Lighting

817 Where interior lighting is provided it is to be flame proof in relation to the interior and details are to be submitted for approval. No wiring is to be fitted inside the crank case.

Hydraulic Tests

818 Where main and auxiliary engine cylinder covers and cylinders not fitted with liners cannot be readily examined internally they are to be tested by hydraulic pressure to 1·5 times the maximum working pressure.

819 Air compressor cylinders, covers, intercoolers and aftercoolers are to be tested by hydraulic pressure to twice their maximum working pressure.

820 Cylinder liners are to be tested by hydraulic pressure to not less than 100 lb. per square inch.

821 The water jackets of cylinders, and the cooling passages of cylinder covers and pistons, are to be tested by hydraulic pressure to 30 lb. per square inch.

822 Fresh water and lubricating oil coolers are to be tested by hydraulic pressure to twice the working pressure with a minimum of 50 lb. per square inch on the fresh water and lubricating oil side, and a minimum of 30 lb. per square inch on the cooling water side.

Cross-references

823 Engines intended for driving electric generators are to comply with the requirements of L 4 and M 2 where applicable.

824 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

825 The pumping arrangements, cooling water and lubricating oil systems are to comply with the requirements of Chapter E.

826 All oil fuel pipes, tanks and their fittings are to comply with the requirements of D 20 and Chapter E.

18th March, 1954

Section 9

SPARE GEAR

901 For lists of spare gear to be carried, *see* Chapter K.

Section 10

PERIODICAL SURVEYS

1001 For periodical survey requirements, *see* C 4 and C 6.

TABLE I. FOR CRANK SHAFTS

Maximum Pressure 500 lb. per square inch and above

SINGLE ACTING ENGINES		
NUMBER OF CYLINDERS		C
4 STROKE CYCLE	2 STROKE CYCLE	
1, 2, 3 or 4	1 or 2	7·3
5 or 6	3	7·7
7 or 8	4	8·6
9 or 10	5	9·3
11 or 12	6	9·6
—	7	9·8
—	8	10·0
—	9	11·2
—	10	12·3
—	11	12·7
—	12	13·5

DOUBLE ACTING ENGINES		
NUMBER OF CYLINDERS		C
2 STROKE CYCLE		
3		7·2
4		13·4
4		8·7
5		11·3
6		13·1
6		12·0
6		16·6
7		13·8
8		15·4
8		29·3
9		16·8
10		19·4
10		25·0
11		22·0
12		23·0
12		28·9

TABLE II. FOR INTERMEDIATE SHAFTS OF 4 STROKE CYCLE SINGLE ACTING ENGINES

Maximum Pressure 500 lb. per square inch and above

NUMBER OF CYLINDERS	VALUE OF A	Value of C for following piston speeds in feet per minute.			
		700 and below	850	1000	1200 and above
1, 2, 3 or 4	·001	4·03	4·03	4·03	4·03
	·005	4·90	4·70	4·54	4·41
	·010	5·43	5·07	4·80	4·57
5	·001	3·96	3·96	3·96	3·96
	·005	4·53	4·38	4·26	4·16
	·010	4·85	4·59	4·38	4·26
6	·001	3·90	3·90	3·90	3·90
	·005	4·29	4·18	4·09	4·03
	·010	4·51	4·30	4·18	4·07
	·015	4·64	4·37	4·18	4·07
	No Flywheel or Balance Weights	5·00	4·54	4·29	4·13
7	·001	3·88	3·88	3·88	3·88
	·005	4·14	4·09	3·99	3·99
	·010	4·30	4·14	4·07	3·99
	·015	4·40	4·18	4·07	3·99
	No Flywheel or Balance Weights	4·63	4·29	4·12	4·03
8	·001	3·85	3·85	3·85	3·85
	·005	4·06	4·00	3·95	3·92
	·010	4·15	4·04	3·98	3·92
	·015	4·21	4·04	3·98	3·92
	No Flywheel or Balance Weights	4.35	4·12	4·02	3·96
9	·001	3·84	3·84	3·84	3·84
	·005 to ·015	4·04	3·96	3·92	3·90
	No Flywheel or Balance Weights	4·15	4·02	3·96	3·91
10	·001	3·82	3·82	3·82	3·82
	·005 to ·015	3·92	3·89	3·86	3·86
	No Flywheel or Balance Weights	4·01	3·93	3·90	3·86
11 and 12	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80

TABLE III. FOR INTERMEDIATE SHAFTS OF 2 STROKE CYCLE SINGLE ACTING ENGINES

Maximum Pressure 500 lb. per square inch and above

NUMBER OF CYLINDERS	VALUE OF A	Value of C for following piston speeds in feet per minute.			
		700 and below	850	1000	1200 and above
1 or 2	·001	4·05	4·05	4·05	4·05
	·005	5·13	5·00	4·85	4·71
3	·001	3·90	3·90	3·90	3·90
	·005	4·47	4·32	4·27	4·18
	·010	4·88	4·64	4·46	4·31
4	·001	3·87	3·87	3·87	3·87
	·005	4·16	4·09	4·04	4·00
	·010	4·38	4·25	4·11	4·05
	·015	4·51	4·29	4·16	4·05
5	·001	3·84	3·84	3·84	3·84
	·005	3·97	3·94	3·90	3·90
	·010	4·07	4·00	3·93	3·90
	·015	4·11	4·03	3·93	3·90
	No Flywheel or Balance Weights	4·25	4·10	4·00	3·92
6	·001	3·82	3·82	3·82	3·82
	·005 to ·015	3·86	3·86	3·86	3·86
	No Flywheel or Balance Weights	3·94	3·86	3·86	3·86
7, 8, 9, 10, 11 and 12	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80

TABLE IV. FOR INTERMEDIATE SHAFTS OF 2 STROKE CYCLE DOUBLE ACTING ENGINES

Maximum Pressure 500 lb. per square inch and above

NUMBER OF CYLINDERS		VALUE OF A	Value of C for following piston speeds in feet per minute.			
			700 and below	850	1000	1200 and above
3		·001	3·86	3·86	3·86	3·86
		·005	4·09	4·04	3·99	3·99
		·010	4·28	4·15	4·07	4·01
		·015	4·39	4·25	4·10	4·04
		No Flywheel or Balance Weights	4·89	4·47	4·25	4·09
4		·001	3·91	3·91	3·91	3·91
		·005	4·30	4·19	4·09	4·04
		·010	4·54	4·33	4·18	4·09
		·015	4·66	4·40	4·25	4·09
		No Flywheel or Balance Weights	5·08	4·60	4·32	4·16
4		·001	3·85	3·85	3·85	3·85
		·005	3·94	3·91	3·88	3·88
		·010	4·01	3·95	3·91	3·88
		·015	4·05	3·97	3·91	3·88
		No Flywheel or Balance Weights	4·15	4·01	3·95	3·91
5		·001	3·82	3·82	3·82	3·82
		·005 to ·015	3·90	3·82	3·82	3·82
		No Flywheel or Balance Weights	3·95	3·90	3·86	3·86
6		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·91	3·88	3·84	3·84
		No Flywheel or Balance Weights	3·95	3·91	3·88	3·84
6		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·88	3·84	3·84	3·84
		No Flywheel or Balance Weights	3·91	3·87	3·84	3·84
6		·001	3·90	3·90	3·90	3·90
		·005	4·23	4·09	4·03	3·99
		·010	4·37	4·18	4·07	3·99
		·015	4·45	4·24	4·09	4·01
		No Flywheel or Balance Weights	4·66	4·31	4·13	4·04
7, 8, 9, 10, 11 and 12	EQUAL CRANK ANGLES	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80
8		·001	4·01	4·01	3·97	3·95
		·005	4·41	4·24	4·09	4·02
		·010	4·56	4·29	4·13	4·05
		·015	4·62	4·32	4·15	4·05
		No Flywheel or Balance Weights	4·78	4·39	4·18	4·07
10		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·94	3·90	3·86	3·86
		No Flywheel or Balance Weights	3·98	3·91	3·88	3·86
12		·001	3·80	3·80	3·80	3·80
		·005 to ·015 & No Flywheel or Balance Weights	3·89	3·86	3·84	3·84

Chapter J

BOILERS AND OTHER PRESSURE VESSELS

CYLINDRICAL BOILERS

Section 1

GENERAL REQUIREMENTS

101 In the design and construction of boilers the following conditions are to be observed.

102 The materials used are to be in accordance with the relevant requirements of Chapter P.

103 Where the joints in the shells of boilers are made by means of welding, the shells are to be constructed in accordance with the requirements of J 18 to J 23, in so far as they are applicable.

104 Where the joints in the shells of boilers are riveted, the shells are to be constructed in accordance with the requirements of J 5.

105 All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently heat treated.

106 Butt straps are to be cut from plates and not from rolled strips.

107 All rivet holes are to be drilled, and as far as possible they are to be drilled in place. After drilling the plates the burrs are to be removed and the faying surfaces of the plates cleaned, and the sharp outer edges of holes also removed.

108 Steel stays are not to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars are to be subsequently annealed throughout. In double-ended boilers the through longitudinal stays are to be supported at or near the middle of their length.

109 Screw stays of combustion chambers where fitted with nuts are to be, as far as possible, normal to the chamber plates. Where this is not possible they are to be fitted with taper washers to provide a fair bed for the nuts.

110 Nuts to screw stays in combustion chambers are to be not less than $\frac{3}{4}$ inch thick for stays up to $1\frac{1}{2}$ inches diameter over threads, $\frac{7}{8}$ inch thick for $1\frac{5}{8}$ and $1\frac{3}{4}$ inch stays, 1 inch thick for $1\frac{7}{8}$ and 2 inch stays, and $1\frac{1}{8}$ inches thick for stays over 2 inches in diameter. The nuts are to be made of solid mild steel or of iron which is to be without weld. The nuts for longitudinal stays are to be to the British standards appropriate to the diameters of the stays, the outside nuts having the thickness therein provided for ordinary nuts, and the inside nuts having the thickness provided for lock nuts.

111 Screw stays $1\frac{1}{4}$ inches in diameter and above should have 9 threads per inch, and all stays 2 inches in diameter and above passing through plates, and secured by nuts on each side of the plate, should have not more than 6 threads per inch.

112 Where jointed longitudinal stays are fitted between the front and back tube plates they are to be fitted with pins having an effective sectional area not less than 25 per cent in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than $\frac{1}{16}$ inch. The pins are to be as close as possible to the shoulder of the eye forging. The shoulder of the forging is to have a diameter not less than 1 inch greater than the diameter of the hole.

113 The end plates in the steam space in way of uptakes are to be shielded from contact with the heated gases.

Cross-reference

114 For requirements as to smoke box doors and the omission of dampers in oil fired boilers, *see* E 328 and E 329.

Section 2

ACCESS ARRANGEMENTS

201 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided and is to be such that the strength in way of the hole is not less than that required for the longitudinal joint.

202 Where a flat plate is flanged for stiffening it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured in inches from the outer surface is to be at least equal to $\sqrt{T \times W}$
where T is the thickness of the plate in inches and W is the minor axis of the hole in inches.

203 The doors to manholes, mudholes, and sight holes are to be built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess

is not to have a greater clearance than $\frac{1}{16}$ inch all round, i.e., the axes of the opening are not to exceed those of the door by more than $\frac{1}{8}$ inch.

204 The studs for securing all doors are to be screwed through the plate, and they are to be fitted with nuts on the inside or bolts may be used screwed through the plate with the heads inside.

205 All boilers are to be provided, where possible, with means for ingress to permit of examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit of this there are to be sight holes and mudholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

206 Where the cross tubes of vertical boilers are large there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

Section 3

HYDRAULIC TESTS

Boilers

301 In all new boilers working at pressures up to 100 lb. per square inch the hydraulic test is to be twice the working pressure. For boilers working at pressures greater than 100 lb. per square inch the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Boiler Mountings

302 All boiler mountings are to be subjected to a hydraulic test of twice the working pressure with the exception of feed check valves which are to be tested to 2·5 times the working pressure. The test pressures need not, however, be more than 1000 lb. per square inch above the working pressure.

Section 4

BOILER MOUNTINGS AND FITTINGS

General

401 Valves over $1\frac{1}{2}$ inches diameter are to be fitted with outside screws and the covers are to be secured by bolts or studs. All valves are to be arranged to be shut with a right-hand (clockwise) motion of the wheels.

402 All cocks and valves connected to the boiler are to be such that it is seen without difficulty whether they are open or shut. Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a length of at least one diameter. If the stud hole penetrates the whole thickness of the plate the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings they are to be screwed right through the plate with their heads inside the boiler.

403 Where a superheater is fitted which can be shut off from the boiler it is to be provided with a separate safety valve fitted with easing gear. The valve as regards construction is to comply with the regulations for ordinary safety valves, but the easing gear may be fitted to be workable from the stokehold only. The superheater is also to be fitted with a drain cock or valve to free it from water when necessary.

404 Safety valve chests and other boiler and superheater mountings subjected to pressures exceeding 150 lb. per square inch or to steam temperatures exceeding 425° F., and boiler blow down fittings, are to be made of steel or other approved material.

Safety Valves

405 Boilers are to be fitted with not less than two safety valves, each having a minimum diameter of $1\frac{1}{2}$ inches, but vertical boilers having a total heating surface of less than 100 square feet may have one valve not less than 2 inches diameter.

406 The safety valves are to be so arranged that the springs and valves are cased in, that the valves cannot be overloaded when steam is up, that they can be lifted by easing gear and turned round on their seats by hand, and that in the case of fracture of springs they cannot lift out of their seats. The easing gear is to be operated by mechanical means from the boiler or engine room platforms.

Pilot valves which admit steam to their respective full lift valves are to be provided with suitable locking devices.

407 All the safety valves of each boiler may be fitted in one chest, which is to be separate from any other valve chest and is to be connected direct to the boiler by a strong and stiff neck, the passage through which is to be of not less cross sectional area than the aggregate area of the safety valves in the chest in the case of full lift valves and one-half of that area in the case of other valves. Each safety valve chest is to be provided with a means by which it can be drained ; the drain pipe is to be led to the bilge or to a tank, clear of the boiler.

Saturated Steam

408 The minimum aggregate area of the orifices through the seatings of the safety valves on each boiler, whether coal fired, oil fired and/or exhaust gas fired and

whether working under natural, forced or induced draught, is to be found by the following formula :—

$$A = \frac{T.H.S. \times E}{(p + 15) \times C}$$

where A = *for ordinary, high lift or improved high lift safety valves*, the aggregate area in square inches of the orifices through the seatings of the valves
for full lift safety valves, the net area in square inches through the seats after deducting the area of the guides or other obstructions when the valves are fully lifted,

T.H.S. = total external surface in square feet of the tubes and other parts of the boiler exposed to heat, so as to cause evaporation,

p = working pressure, in lb. per square inch,

E = estimated evaporation, in lb. per square foot of heating surface (T.H.S.) per hour, with a minimum value of 6, where the boilers are coal fired or oil fired and a minimum value of 3 for those parts of the boiler heated exclusively by exhaust gases,

C = 4·8 for valves of ordinary type,
7·2 for valves of high lift type,
9·6 for valves of improved high lift type,
19·2 for valves of full lift type.

In cases where the capacity of a high discharge type safety valve has been established by test, special consideration will be given, if desired, to the use of a higher constant than C=19·2, up to a maximum of C=30 for full bore safety valves.

Superheated Steam

409 For valves which have to pass superheated steam, the aggregate area of the valves is to be the area A required by 408, multiplied by the factor :—

$$\left(1 + \frac{T}{1000}\right)$$

where T = degree of superheat, in degrees Fahrenheit.

410 An approved type of safety valve of equally good and reliable design may be fitted in lieu of those described in this Section.

Waste Steam Pipe

411 For ordinary, high lift and improved high lift type valves, the cross-sectional area of the waste steam pipe and passages leading to it, is to be not less than 10 per cent greater than the aggregate area of the safety valves as calculated by the foregoing formulæ ; for other valves, the cross-sectional area of the waste steam pipe and passages is to be not less than twice the aggregate valve area where C=19·2, and three times the aggregate valve area where C=30.

Accumulation Tests

412 All safety valves are to be set under steam to a pressure not greater than 3 per cent above the approved working pressure of the boiler. During a test of 15 minutes with the stop valves closed and under full firing conditions the accumulation of pressure is not to exceed 10 per cent of the loaded pressure. During this test no more feed water should be supplied than is necessary to maintain a safe-working water level.

413 For accumulation tests on the safety valves of water tube boilers, *see* J 1703 and J 1704.

Stop Valves

414 One main stop valve is to be fitted to each boiler secured direct to the shell. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell more than is absolutely necessary. The arrangement, however, is to be such that where more than one boiler is fitted it is possible to supply the steam whistle, the steam steering gear, and the electric light machinery from at least two boilers.

Water Level Indicators on Cylindrical Boilers

415 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass gauge. The other means is to be either an additional glass gauge or an approved equivalent device.

On double-ended boilers the above two water level indicators are to be fitted at each end, one indicator being positioned on each side.

On single-ended boilers, the water level indicators are also to be fitted one on each side of the boiler.

416 A set of not less than two test cocks will be accepted as the approved equivalent device mentioned in 415, for boilers having a working pressure less than 120 lb. per square inch or an internal diameter less than 6 feet.

The test cocks are to be fitted, where practicable, direct to the boiler plating.

417 The water gauges are to be readily accessible and placed so that the water level is clearly visible.

The lowest visible part of the glass of the water gauge and the lower test cock, where test cocks are fitted, are to be situated at the lowest safe working water level.

418 The level of the highest part of the effective heating surfaces, e.g. combustion chamber top of a horizontal boiler and the furnace crown of a vertical boiler, is to be clearly marked in a position adjacent to the glass water gauge.

419 The cocks of all water gauges are to be accessible from positions free from danger in the event of the glass breaking.

420 If the water gauges are not fitted directly to the shell of the boiler but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell. For boilers exceeding 10 feet in diameter the pillars are to be not less than $2\frac{1}{2}$ inches and the connecting pipes not less than $1\frac{1}{2}$ inches internal diameter. For boilers exceeding 7 feet 6 inches but not exceeding 10 feet in diameter the pillars are to be not less than 2 inches and the pipes not less than $1\frac{1}{4}$ inches internal diameter, and for boilers 7 feet 6 inches in diameter and under the pillars are to be not less than $1\frac{3}{4}$ inches and the pipes not less than 1 inch internal diameter. The upper ends of the connecting pipes are to be so arranged that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 2 inches clear of the pipe all round, open for ventilation.

421 For water level indicators on water tube boilers, *see* J 1706 and J 1707.

Feed Check Valves

422 Each boiler is to be provided with a main feed check valve and an auxiliary feed check valve, which are to be attached, wherever practicable, direct to the boiler.

Where the arrangements necessitate the use of stand-pipes between the boiler and the check valves, these pipes are to be of steel or other approved material.

423 For boiler feed water systems, *see* E 7, and for feed water fittings on water tube boilers, *see* J 1708 and J 1709.

Pressure Gauges

424 Each boiler is to be provided with a separate steam pressure gauge. Double-ended boilers are to be provided with a pressure gauge at each end. The gauges are to be placed where they are easily seen.

Blow-off and Scum Valves

425 Each boiler is to be fitted with a blow-off valve secured direct to the shell. The valve and its connections to the sea need not be more than $1\frac{1}{2}$ inches in diameter, and may be generally about $\frac{1}{16}$ inch in diameter for each foot in diameter of the boiler. It is, however, not to be less than $\frac{3}{4}$ inch in diameter. Vertical boilers are to be fitted with a blow-off cock or valve.

426 Blow-off valves and scum valves (where these latter are fitted) of two or more boilers may be connected to one common discharge, but where thus arranged there are to be screw-down non-return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

For blow-off cock or valve on ship's side and attachments, *see* E 267 and E 268.

Salinometer Cock or Valve

427 Each boiler is to be provided with a salinometer cock or valve secured direct to the boiler in a convenient position. The cock or valve is not to be on the water gauge standpipe.

Section 5

RIVETED CYLINDRICAL SHELLS

501 For the cylindrical shells of steel marine boilers the maximum working pressure (which is designated by WP and is in lb. per square inch) to be allowed is to be calculated from the following formulæ:—

Where the thickness of the shell plates does not exceed $1\frac{3}{4}$ inches,

$$WP = \frac{(t-2) \times S \times J}{C \times D}$$

Where the thickness of the shell plates exceeds $1\frac{3}{4}$ inches and the longitudinal seams are made with double butt straps.

$$WP = \frac{t \times S \times J}{2{\cdot}85 \times D}$$

In these formulæ

t = thickness of the shell plates, in 32nds of an inch,

S = minimum tensile strength of the steel shell plates, in tons per square inch,

J = percentage of strength of the longitudinal seams calculated by the methods described in 502,

D = inside diameter of the outer strake of plating of the cylindrical shell, measured in inches,

C = 2·75 where the longitudinal seams are made with double butt straps,
2·83 where the longitudinal seams are made with lap joints and are treble riveted,
2·9 where they are made with lap joints and are double riveted,
3·3 where they are made with lap joints and are single riveted.

502 The percentage of strength of a riveted joint (J) is found from the following formulæ, the first two being applicable to any type of joint, and the third to that type of joint in which the number of rivets in the inner rows is double that in the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint.

$$\left.\begin{array}{l}\text{Percentage of strength of plate at}\\ \text{joint as compared with solid plate}\end{array}\right\} = \frac{100\,(p-d)}{p}$$

$$\left.\begin{array}{l}\text{Percentage of strength}\\ \text{of rivets as compared}\\ \text{with solid plate}\end{array}\right\} = \frac{100\,(S_2 \times a \times n \times C)}{S_1 \times p \times T}$$

Percentage of combined strength of the plate at the inner row of rivet holes and of the rivets in the outer row

$$= \frac{100\,(p-2d)}{p} + \frac{100\,(S_2 \times a \times C)}{S_1 \times p \times T}$$

where p = pitch of rivets at outer rows, in inches,
d = diameter of rivet holes, in inches,
a = sectional area of one rivet, in square inches,
n = number of rivets which are fitted in the pitch p,
T = thickness of plate, in inches,
S_1 = minimum tensile strength of plates, in tons per square inch,
S_2 = shearing strength of rivets, which is taken generally to be 23 tons per square inch, and may be 85 per cent of the minimum tensile strength of the rivet bars,
C = 1·0 for rivets in single shear as in lap joints, 1·875 for rivets in double shear as in double butt-strapped joints.

503 Where the longitudinal seams are fitted with double butt-strapped joints, the outer butt strap is to be at least ·625 of the strength of the plate, and is to be of sufficient thickness to permit of efficient caulking of its outer edges. The inner butt strap is to be $\frac{4}{32}$ inch thicker than this.

In cases where the number of rivets in the inner rows is double the number in the outer row, this will require the minimum thickness, in inches, of the outer strap (t_o) to be

$$t_o = \frac{5 \times (p-d)}{8 \times (p-2d)} \times T$$

and that of the inner strap (t_n) to be

$$t_n = \left\{ \frac{5 \times (p-d)}{8 \times (p-2d)} \times T \right\} + \tfrac{4}{32} \text{ inch.}$$

504 In all cases the clear space between a rivet hole and the edge of a plate is to be not less than the diameter of the rivet holes, i.e., the centre of the rivet hole is to be at least 1·5 diameters distant from the edge of the plate.

In joints whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets is to be not less than ·33p + ·67d with zigzag riveting, or 2d with chain riveting.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between the outer rows and the next rows is to be not less than ·33p + ·67d or 2d, whichever is the greater, and the distance between the rows in which there are the full number of rivets is to be not less than 2d.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zigzag, the distance between the outer rows and the next rows is to be not less than ·2p + 1·15d, and the distance between the rows in which there are the full number of rivets is to be not less than ·165p + 0·67d.

In the above p is the pitch of the rivets in the outer rows.

505 The maximum pitch, in inches, of the rivets in the longitudinal joints of boiler shells

$$= (C \times T) + 1\tfrac{5}{8} \text{ inches}$$

where T is the thickness of the plate in inches and C is a coefficient as given in the following Table :—

Number of rivets per pitch	Coefficients for lap joints	Coefficients for double butt-strapped joints
1	1·31	1·75
2	2·62	3·50
3	3·47	4·63
4	4·14	5·52
5	—	6·00

506 If holes are cut in the cylindrical shells of boilers for fixing of mountings, the diameters of the holes being greater than 2·5 times the thickness of the shell plating plus $2\frac{3}{4}$ inches, compensation is to be fitted as in the case of manholes. (*See* J 201.)

507 Where more than three screw stays pierce the cylindrical shell in a horizontal line, if d is their diameter and p the pitch, $\frac{100\,(p-d)}{p}$ should not be less than the percentage of strength required for the shell longitudinal joints. If this is not possible, stays are to be arranged out of line with one another longitudinally.

508 The strength of the seams joining the end plates to the cylindrical shell is not to be less than 42 per cent of that of the solid shell plate. Where the shell plates exceed $\frac{5}{8}$ inch in thickness the seams connecting the shell plates to the end plates are to be at least double riveted. Where the shell plates exceed $\frac{1}{2}$ inch in thickness the intermediate circumferential seams of double-ended boilers are to be at least double riveted.

509 The circumferential seam at or near the middle of the length of single-ended boilers is to have a strength of joint not less than 60 per cent of the solid plate. The inner circumferential seams of double-ended boilers are to have a strength of joint not less than 62 per cent of the solid plate. In any case there are to be at least three rows of rivets where single-ended boilers have shell plates over $1\frac{3}{8}$ inches in thickness and where double-ended boilers have shell plates over $1\frac{3}{16}$ inches in thickness.

510 The circumferential seams of the shells of vertical boilers are to have a strength of not less than 42 per cent of the solid plate. Where these seams are not complete circles, and where the shell plates exceed $\frac{5}{8}$ inch in thickness, the riveting is to be at least double.

Section 6

FURNACES

Note :—Furnaces, plain or corrugated, are not to exceed $\frac{13}{16}$ inch in thickness.

Corrugated Furnaces

601 The working pressure to be allowed on corrugated furnaces is to be determined by the following formula :—

$$WP = \frac{C\,(t-1)}{D}$$

where WP = working pressure, in lb. per square inch,
D = external diameter measured at the bottom of the corrugations, in inches,
t = thickness of the furnace plate, in 32nds of an inch, measured at the bottom of the corrugation or camber,
C = 480 for the Fox, Morison, Deighton Purves and other similar furnaces,
510 for the Leeds Forge Bulb Suspension furnace.

Plain Furnaces and Combustion Chamber Bottoms

602 The working pressure to be allowed on plain furnaces or furnaces strengthened by the Adamson or other joints, and on the cylindrical bottoms of combustion chambers, is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\,(t-1)^2}{(L+24)\times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\,(t-1) - L]$$

where WP = working pressure, in lb. per square inch.
D = external diameter of the furnace or combustion chamber, in inches,
t = thickness of the plate, in 32nds of an inch,
L = length of the furnace or of combustion chamber bottom or the length between points of substantial support, in inches, measured from the centres of the rivet rows or from the commencement of flange curvature, whichever is applicable,
C = 1450 where the longitudinal seams are welded and 1300 where they are riveted,
C_1 = 50 where the longitudinal seams are welded and 45 where they are riveted.

603 Where the furnaces are tapered, the diameter to be taken for calculation purposes is to be the mean of that at the top and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose is to be the distance from the centre of the row of rivets connecting the crown to the body of the furnace, to the substantial support at the bottom of the furnace or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate where the stays are riveted at their ends, and 16 times where they are fitted with nuts. Such screwed stays are to be in diameter over the threads not less than 2·25 times the thickness of the furnace plate.

Furnaces of Spherical Form

604 Where the furnaces are spherical in form and convex upwards at their tops, and are without support from stays of any kind :—

$$WP = \frac{275\,(t-1)}{R}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the top plate, in 32nds of an inch,
R = outer radius of curvature of the furnace in inches.

Uptakes of Vertical Boilers

605 The working pressure to be allowed on internal uptakes of vertical boilers is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\,(t-5)^2}{(L+24)\times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\,(t-5) - L]$$

where WP = working pressure, in lb. per square inch,
D = external diameter of the uptake, in inches,
t = thickness of the uptake, in 32nds of an inch,
L = length of the uptake between points of substantial support, in inches, measured from the centres of the rivet rows,
C = 1450 where the longitudinal seams are welded and 1300 where they are riveted,
C_1 = 50 where the longitudinal seams are welded and 45 where they are riveted.

Cross Tubes

606 The thickness of cross tubes in cross tube boilers is to be determined from the following formula, but is in no case to be less than $\frac{3}{8}$ inch :—

$$t = \frac{WP \times D}{200} + 7$$

where WP = working pressure, in lb. per square inch,
t = minimum thickness, in 32nds of an inch,
D = internal diameter of the cross tube, in inches.

Ogee Rings

607 For the ogee ring which connects the bottom of the furnace to the shell, and sustains the whole load on the furnace vertically :—

$$WP = \frac{140\,(t-1)^2}{D\times(D-d)}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the ogee ring, in 32nds of an inch,
D = inside diameter of the boiler shell, in inches,
d = outside diameter of the lower part of the furnace where it joins the ogee ring, in inches.

Section 7

FLAT PLATES SUPPORTED BY STAYS SECURED IN VARIOUS WAYS

701 The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula :—

$$WP = \frac{(t-1)^2 \times C}{a^2 + b^2}$$

In this formula and in the formulæ in 708 to 711

WP = working pressure, in lb. per square inch,
t = thickness of the flat plate, in 32nds of an inch,
t_w = thickness of the washers, strips, or doublings employed, in 32nds of an inch,
a = distance apart of the rows of stays, in inches,
b = pitch of the stays in the rows, in inches,
C is a coefficient which varies with the method of fixing the stays as follows :—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over, C = 50. Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over, C = 57. In these cases the thickness of the plate is to be at least half the diameter of the stay required by the Rules.

Where stay tubes are screwed into tube plates and expanded, C = 52. If they are fitted with nuts, C = 72.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside, C = 75. Where the plates are not exposed to flame, C = 86.

Where the stays pass through the plates not exposed to flame and are fitted with nuts inside and outside, C = 96, and where the plates are exposed to flame, C = 84.

702 Where plates are stiffened by flanging, the inner radius of which is not greater than 2·5 times the thickness of the plate, for the support thus given C = 110 where the plates are not exposed to flame and C = 96 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

703 For portions of plate where the stays are irregularly pitched d^2 is to be used instead of $a^2 + b^2$, d being the diameter of the largest circle which can be drawn passing through not less than three points of support, i.e., the centres of stays or the commencement of the curvature of flanging whichever is applicable. In this case C is to be taken as the mean of the values appropriate for the points of support.

704 For the tops and sides of combustion chambers the distance between the rows of stays nearest to the back tube plate or the back plate respectively and the commencement of curvature of these plates at their flanges is to be not greater than a.

705 The stays of the combustion chambers are to be so placed that the seams of the plates can be caulked without removing the stay nuts.

706 For the tops of combustion chambers where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate is not to exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder is to be not more than half the allowable distance between the girders.

707 Where portions of plate are supported by stays secured in different ways the value of C to be taken is the mean of the values appropriate to the method of securing the supporting stays.

708 Where the plate is supported by stays which pass through it and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3·5 times that of the stay, and their thickness at least two-thirds of that of the plate but not greater than that of the plate :—

$$WP = \frac{100}{a^2 + b^2} [(t - 1)^2 + \cdot 15\ t_w^2]$$

709 Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2} [(t - 1)^2 + \cdot 35\ t_w^2]$$

710 Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth and having a thickness at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2} [(t - 1)^2 + \cdot 55\ t_w^2]$$

711 Where the plate is fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2} [(t - 1)^2 + \cdot 85\ t_w^2]$$

712 For the portions of tube plates in the nests of tubes :—

$$WP = \frac{C\ (t - 1)^2}{p^2}$$

where WP = working pressure, in lb. per square inch,

t = thickness of the tube plate, in 32nds of an inch,

p = mean pitch, in inches, of the stay tubes supporting any portions of the plate (being the sum of the four sides of the quadrilateral divided by 4),

C = 38 where the stay tubes are screwed and expanded into the plate and nuts are not fitted,

49 where the stay tubes are screwed and expanded into the plate and fitted with nuts. (*See* J 1206.)

713 For the wide water spaces of front tube plates between the nests of tubes and between the wing rows of tubes and the shell :—

$$WP = \frac{C[(t-1)^2 + \cdot 55 t_w^2]}{a^2 + b^2}$$

where WP = working pressure, in lb. per square inch,

t = thickness of the front tube plate, in 32nds of an inch,

t_w = thickness of the doubling plate, where so fitted, in 32nds of an inch,

a = horizontal pitch of stay tubes, in inches, measured across the wide water space,

b = vertical pitch of stay tubes in the bounding rows, in inches, measured from centre to centre,

C = 52 where the stay tubes are screwed and expanded into the tube plate and nuts are not fitted,
72 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted to each stay tube,
63 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted only to alternate stay tubes.

714 If steel of less strength than 26 tons per square inch is used for flat plates, the working pressure allowed is to be correspondingly reduced.

Section 8

TUBE PLATES UNDER COMPRESSION

801 The pressure to be allowed on tube plates is to be calculated by the following formula, in which the compressive stress is taken at 14,000 lb. per square inch :—

$$WP = 875 \times \frac{(D - d) \times t}{W \times D}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the tube plate, in 32nds of an inch,
D = horizontal distance apart of the tubes, centre to centre, in inches,
d = internal diameter of the plain tubes, in inches,
W = width of combustion chamber, in inches, measured inside from tube plate to back chamber plate, or between tube plates in double-ended boilers with combustion chambers common to two opposite furnaces.

Section 9

TUBE PLATES OF VERTICAL BOILERS

901 Where vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes are to be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

902 Each alternate tube in the outer vertical rows of tubes is to be a stay tube. The tube plates between the stay tubes are to be in accordance with J 712 and in addition :—

$$WP = \frac{(t - 2) \times S \times (p - d) \times 100}{2{\cdot}9 \times D \times p}$$

where WP = working pressure, in lb. per square inch,
S = minimum tensile strength of the steel plate, in tons per square inch,
t = thickness of the tube plate, in 32nds of an inch,
D = twice the radial distance of the centre of the outer row of tube holes from the axis of the shell, in inches,
p = vertical pitch of tubes, in inches,
d = diameter of the tube holes, in inches.

The least working pressure obtained by the above formula and that in J 712 is to be taken.

Section 10

GIRDERS

1001 For girders supporting the tops of combustion chambers the following formula is to be used :—

$$WP = \frac{C \times d^2 \times t}{(L - P) \times D \times L} \times \frac{S}{28}$$

where WP = working pressure, in lb. per square inch,
d = depth of the girder at centre, in inches,
t = thickness of the girder at centre, where this is a forging, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in 32nds of an inch,
L = length of the girder, in inches, measured between the tube plate and back chamber plate inside, or between tube plates in chambers common to two opposite furnaces,
P = pitch of stays supported by the girder, in inches,
D = distance apart of the girders, centre to centre, in inches,
S = minimum tensile strength of the material forming the girder, in tons per square inch.

$C = \frac{n}{n + 1} \times 495$, where the number of stays (n) in each girder is odd,

$\frac{n + 1}{n + 2} \times 495$, where the number of stays (n) in each girder is even.

Section 11

STAYS

Screw Stays

1101 For screw stays with threads not coarser than 9 threads per inch, made of steel or of special wrought iron tested to the requirements of P 8, the following formula is to be used, but in no case is the stress to exceed 9,000 lb. per square inch :—

$$WP = \frac{(d - \cdot 267)^2 \times 8250}{a}$$

where WP = working pressure, in lb. per square inch,

d = diameter of the stay over the thread, in inches,

a = area, in square inches, supported by one stay.

Longitudinal Stays

1102 For steel longitudinal stays with threads not coarser than 6 threads per inch the working pressure is to be calculated from the following formula, but in no case is the stress to exceed 11,000 lb. per square inch where steel of a minimum tensile strength of 28 tons per square inch is used :—

$$WP = \frac{(d - \cdot 340)^2 \times 9500}{a} \times \frac{S}{28}$$

where WP = working pressure, in lb. per square inch,

d = diameter of the stay over the thread, in inches,

a = area, in square inches, supported by one stay,

S = minimum tensile strength of the steel, in tons per square inch.

1103 In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per inch are used, the working pressure is to be calculated from the following formula :—

$$WP = \frac{(d^1 - \cdot 125)^2 \times 9500}{a} \times \frac{S}{28}$$

d^1 = diameter of the stay at the bottom of the thread, in inches, or at the smallest part of the body.

Other symbols as defined in 1102.

Cross-reference

1104 *See* also requirements of J 108 to J 112.

Section 12

BOILER TUBES, PLAIN AND STAY, AND SUPERHEATER TUBES

1201 Where tubes are made of steel, the material is to comply with the relevant requirements of P 13.

1202 The following table gives the working pressures permissible with plain boiler tubes of standard thicknesses, whether of lapwelded wrought iron or of lapwelded or seamless mild steel :—

Outside diameter of tube in inches	Standard thicknesses in L. S. G.				Working pressures in lb. per square inch			
	A	B	C	D	A	B	C	D
2		11	10	9		155	215	300
$2\frac{1}{4}$	11	10	9	8	140	190	260	330
$2\frac{1}{2}$	11	10	9	8	125	175	230	300
$2\frac{3}{4}$	11	10	9	8	110	160	215	275
3	10	9	8	7	140	190	250	300
$3\frac{1}{4}$	10	9	8	7	130	180	230	280
$3\frac{1}{2}$	10	9	8	7	120	165	215	260

1203 On stay tubes, whether of wrought iron or of steel, a working stress of 7,500 lb. per square inch of the net sectional area at the bottom of the thread is allowed.

1204 The minimum thickness of stay tubes measured under the threads is to be $\frac{1}{4}$ inch for marginal stay tubes and $\frac{3}{16}$ inch for other stay tubes.

1205 Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The pitch of the thread is to be not finer than 10 threads per inch. It is desirable however that they should be screwed to the standard 9 threads per inch. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

1206 Nuts are not to be fitted to stay tubes at the combustion chamber end.

1207 If stay tubes are increased in thickness at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

Tubes for Superheaters attached to Cylindrical Boilers

1208 The minimum thickness of the tubes is to be calculated by the following formula :—

$$t = \frac{WP \times d}{75} + 7$$

where WP = working pressure in the boiler, in lb. per square inch.
d = external diameter, in inches.
t = thickness, in 100ths of an inch.

Section 13

DISHED END PLATES WITHOUT STAYS

1301 For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates dished to partially spherical form subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the working pressure to be allowed is to be determined by the following formula or, if desired, by the formula in J 1604 :—

$$WP = \frac{480 \times S(T - \cdot 03)}{R}$$

where WP = working pressure, in lb. per square inch,
T = thickness of the end, in inches, after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material,
S = minimum tensile strength of the material, in tons per square inch,
R = inside radius of curvature of end, in inches, which is not to exceed the outside diameter of drum end.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than $2\frac{1}{2}$ inches.

1302 Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

1303 Where the end is provided with a flanged manhole the thickness of the end in inches obtained by the formulæ in 1301 is to be increased by $\frac{1}{8}$ inch and the depth (F) of the manhole flange, measured in inches from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in inches,
W = minor axis of the manhole, in inches.

1304 Where the end is provided with large openings for branches, mountings, or unflanged manholes the thickness of the end, as determined by the formulæ in 1301, is to be increased by $\frac{1}{8}$ inch and adequate compensation is to be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1305 Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

1306 Where the end or crown is a complete hemisphere without stays or other supports, and is made in more than one plate, the working pressure to be allowed is given by the following formula :—

$$WP = \frac{(t - 2)\,S \times J}{C \times R}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the plates, in 32nds of an inch,
S = minimum tensile strength of the steel plates, in tons per square inch,
J = strength of riveted joint as a percentage of the solid plate,
R = inner radius of curvature, in inches,
C = 2·83 for treble riveted,
2·9 for double riveted,
3·3 for single riveted.

WATER TUBE BOILERS

Section 14

GENERAL REQUIREMENTS

1401 In the design and construction of water tube boilers intended for working pressures up to 1,500 lb. per square inch the following conditions are to be observed.

Materials

1402 The materials are to comply with the relevant requirements of Chapter P.

Where it is proposed to use alloy steels for superheater headers or tubes, particulars of the appropriate British or other national standard material specifications with details of the chemical compositions, heat treatment and mechanical properties are to be submitted for consideration.

1403 Where the material does not conform to an established standard, particulars of the long-term creep and rupture data at the operating temperature are to be submitted in addition to the details required by 1402 for the purpose of assessing a safe working stress.

If the long-term creep data has been estimated, details of the method of estimation are also to be submitted.

Particulars of scaling and corrosion resistance of the material under the operating conditions are to be submitted when required.

Protection of Drums and Headers

1404 Where any parts of the boiler drums or headers are not protected by tubes and are exposed to radiation from the fire, or to the impact of hot gases, they are to be protected by a shield of good refractory materials or by other approved means.

Access Arrangements

1405 Manholes are to be provided in all drums of sufficient size to permit of access for internal examination and cleaning and for fitting and expanding the tubes. In the case of headers for water walls, superheaters or economisers and of drums which are too small to permit entry, sight holes or mud holes sufficiently large and numerous for these purposes are to be provided.

1406 Doors for manholes, mud holes and sight holes are to be formed from steel plate or of other approved construction and all jointing surfaces are to be machined.

The doors are to be of the internal type and are to be provided with spigots which have a clearance of not more than $\frac{1}{16}$ inch all round, i.e. the axes of the opening are not to exceed those of the door by more than $\frac{1}{8}$ inch.

1407 Doors for openings not larger than 9 inches × 7 inches need only be fitted with one stud which may be forged integral with the door. Larger doors are to be provided with two studs screwed through the door and fitted with nuts on the inside or alternatively, bolts may be used screwed through the door with the heads inside; other methods of attachment may be accepted provided details are submitted for consideration.

The crossbars or dogs are to be of steel.

For smaller circular openings in headers and similar fittings an approved type of plug may be used.

Section 15

CONSTRUCTION OF WATER TUBE BOILERS

Seamless Drums

1501 Seamless forged drums are to be made in accordance with the requirements of P 11.

Welded and Riveted Drums

1502 Drums of welded construction are to be made in accordance with the requirements of J 18 to J 23 in so far as they are applicable.

1503 Drums of riveted construction are to be made in accordance with the requirements of J 5. Where the internal diameters of the drums are less than 100 times the thickness of the plating at the seams, the type of longitudinal joints is to be such that the line of mean thickness of shell plating closely approximates to cylindrical form. Ordinary riveted lap joints are not considered suitable for this purpose.

1504 Drum shell plates are to be of cylindrical form and are to be bent entirely by machine; local heating and hammering is not to be employed. Where the plate is bent to an internal radius of less than 20 times the plate thickness it is to be efficiently heat treated after bending. Drum ends are to be made from one piece of rolled plate.

1505 All steel plates which are dished, flanged or locally heated are afterwards to be annealed or normalised.

Thinning of Plates

1506 Where the tube plate is thicker than the drum shell plate, the tube plate, in way of the longitudinal and circumferential seams, is to be reduced in thickness by an equal amount on each side of the plate to the same thickness as the shell plate. This reduction in thickness is to be gradual and carried out by machining.

The thinning of dished end plates in way of buttwelded joints is also to be carried out by machining but may be made from one side of the plate.

Tube Holes

1507 The tube holes in drums or headers are to be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel seating of at least $\frac{1}{2}$ inch in depth measured in a plane through the axis of the tube at the holes. Where the tubes are practically normal to their plates, this parallel seating is to be not less than $\frac{3}{8}$ inch in depth.

Tube Ends

1508 Tubes are to be carefully fitted in the tube holes and secured by means of expanding and belling or by other approved methods. Tubes are to project through the neck or belt of parallel seating by at least $\frac{1}{4}$ inch and where they are secured from drawing out by means of bellmouthing only the included angle of belling is to be not less than 30°.

Hydraulic Tests

1509 In all new boilers working at pressures up to 100lb per square inch the hydraulic test is to be twice the approved boiler pressure. For boilers working at pressures greater than 100lb per square inch the hydraulic test pressure is to be 1·5 times the approved boiler pressure plus 50lb per square inch.

1510 All boiler mountings are to be subjected to a hydraulic test of twice the approved boiler pressure with the exception of feed check valves and other mountings connected to the main feed system which are to be tested to 2·5 times the approved boiler pressure, or twice the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

Section 16

SCANTLINGS OF DRUMS, ENDS, HEADERS AND TUBES

Cylindrical Shells

1601 When plans of water tube boilers are submitted for approval particulars of the safety valves and their disposition on boiler and superheater, together with the estimated pressure drop through the superheater, are to be stated. The pressures proposed for the settings of boiler and superheater safety valves are to be indicated on the boiler plan.

1602 The thickness of drum shell plates, which are unpierced by tube holes, is to be determined by formula 1. Where, however, the thickness obtained by that formula exceeds 10 per cent of R then formula 2 is to be used. For shells with riveted joints *see* J 5.

$$(1) \qquad t = \frac{WP \times R \times 64}{C \times f} + 2$$

$$(2) \qquad t = \frac{WP \times R \times 64}{(C \times f - WP)} + 2$$

where t = thickness of plate, in 32nds of an inch,

WP = maximum working pressure, in lb. per square inch,

R = internal radius of the shell, in inches,

C is a coefficient having a value of

2 for seamless shells,

1·8 for fusion welded joints and

1·6 for forge welded joints.

f = nominal stress, in lb. per square inch.

For shells with metal temperatures up to and including 650° F., f is to be taken as $\frac{1}{4}$ of the specified minimum tensile strength of the material.

For seamless superheater drums and headers with metal temperatures above 650° F., the nominal stress f is to be taken from Table 1 which gives values for a number of wrought steels of approved composition in common use. Values of f for other steels will receive special consideration, *see* J 1403. When evaluating the stress f, the metal temperature is to be taken as not less than the maximum steam temperature plus 50° F. unless the headers are situated outside the boiler casing.

The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

TABLE 1

NOMINAL STRESSES

MATERIAL		METAL TEMPERATURE °F.							
TYPE	Minimum tensile strength tons per square inch	650	700	750	800	850	900	950	1000
		Values of f = nominal stress, in lb. per square inch.							
Carbon Steel	24	13400	13200	12000	10500	8000	6000	—	—
	28	15700	15200	13400	11300	8600	6000	—	—
	32	17900	17200	14800	12100	9200	6000	—	—
	36	20200	19200	16200	12900	9600	6000	—	—
0·5% Mo. Steel	26	14600	14600	14600	14200	13400	12000	6500	2500
	31	17400	17400	17400	16600	15400	13100	6500	2500

Tube Plates

1603 The thickness of drum tube plates and cylindrical headers which are drilled for tubes is to be determined by the following formula:—

$$t = \frac{WP \times R \times 64}{(1{\cdot}8 \times f \times E - WP)} + 2$$

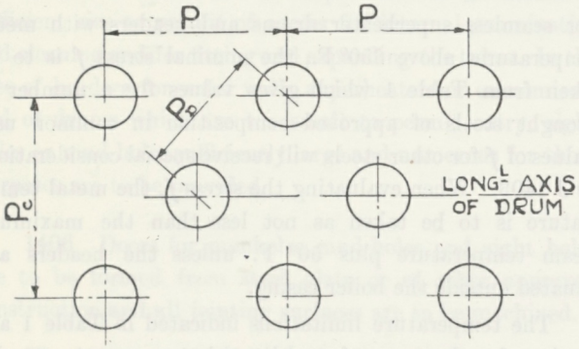
where t, WP and f are as defined in 1602,

R = internal radius of tube plate, in inches,

E = efficiency of ligaments between tube holes expressed as a fraction and calculated in accordance with 1604.

Ligament Efficiency

1604 Where tube plates or header shells are drilled for tubes the ligament efficiency between tube holes shall be determined by the following methods and the lowest value obtained shall be used in the formula of 1603 for tube plate thickness. Method 2 is only applicable where the tube holes are arranged in lines parallel to the axis so as to form a staggered arrangement with diagonal ligaments.



(1) $E = \dfrac{P - d}{P}$

(2) $E = \dfrac{3{\cdot}84 P_D (P_D - {\cdot}95d)^2}{(P^2 + {\cdot}5P_C^2)(P_D - {\cdot}95d) + P \times P_C \times {\cdot}375d}$

where E = ligament efficiency, expressed as a fraction,

P = longitudinal pitch of tube holes, in inches,

P_C = circumferential pitch of tube holes, in inches, in line circumferentially measured at the mid-thickness of the plate,

P_D = diagonal pitch of tube holes, in inches, measured at the mid-thickness of the plate,

d = mean effective diameter of tube holes, in inches.

The circumferential pitch P_C is to be such that the circumferential ligament efficiency is equal to or greater than half the ligament efficiency on the longitudinal axis.

Dished End Plates

1605 Where drum ends for boilers and headers are dished from plates and are subject to pressure on the concave side they are to comply with the following :—

(*a*) For ends dished to partial spherical form the inside radius of dishing, R, is to be not greater than the outside diameter D.

The inside corner radius, r, is to be not less than four times the plate thickness and in no case less than $2\frac{1}{2}$ inches.

(*b*) For ends having no unreinforced opening greater than four times the plate thickness, the working pressure to be allowed is to be determined by the following formula:—

$$WP = \frac{(T - 1) \times f \times h}{3{\cdot}8 \times D^2} \times \left\{ \frac{\frac{r}{R} + {\cdot}05}{\frac{r}{R} + {\cdot}15} \right\}$$

where WP = working pressure, in lb. per square inch,

T = thickness of the end, in 32nds of an inch, after dishing which in no case is to be less than the thickness of an unpierced shell of the same diameter and material,

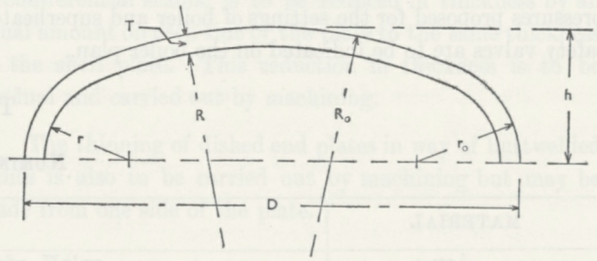
f = nominal stress, in lb. per square inch, having values as stated in 1602,

D = outside diameter of end, in inches,

R = inside radius of dishing, in inches,

r = inside radius of corner, in inches,

h = external height of dishing, in inches, measured from the centre of the corner radius, which is to be calculated as follows:—



$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

R_o = outside radius of dishing, in inches,

r_o = outside radius of corner, in inches.

1606 Proposals to make dished ends of semi-ellipsoidal form will be considered provided details are submitted before the work is commenced.

Flat End Plates

1607 For unstayed flat end plates attached by one of the methods shown in J 18, Fig. 1 the working pressure is to be determined by the following formula :—

$$WP = \frac{(t-1)^2 \times f}{150 \times D^2}$$

where WP = working pressure, in lb. per square inch,
t = thickness of plate, in 32nds of an inch,
f = nominal stress, in lb. per square inch, having values as stated in 1602,
D = inside diameter in inches.

Manhole Compensation

1608 Where a dished end is provided with a flanged manhole the thickness of the end obtained by the formula in 1605 is to be increased by at least 15% but in no case less than $\frac{1}{8}$ inch and the depth of the manhole flange is to be determined as follows :—

$$F = \sqrt{T_1 \times W}$$

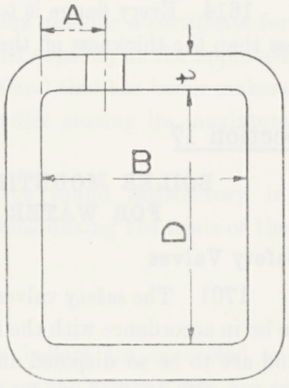
where F = depth of manhole flange, in inches, measured from the outer surface at the minor axis,
T_1 = required thickness of end plate, in inches,
W = minor axis of manhole, in inches.

Headers of Rectangular Section

1609 The working pressure to be allowed for solid drawn and forged headers of rectangular section is to be determined by the following formulæ (1) and (2) whichever gives the lower pressure :—

(1) $$WP = \frac{4 \times f}{\left(\frac{B}{t}\right)^2 + \frac{D}{t}}$$

(2) $$WP = \frac{2 \times f \times E}{K \times \left(\frac{B}{t}\right)^2 + \frac{D}{2 \times t}}$$



where WP = maximum working pressure, in lb. per square inch,
f = nominal stress, in lb. per square inch, having values as stated in 1602,
t = wall thickness, in inches, minus 0·06 inch,
B = internal length, in inches, of the side under consideration,
D = internal length, in inches, of supporting side, at right angles to dimension B,
E = minimum longitudinal efficiency of ligament between tube holes or hand holes, expressed as a fraction,
K is a coefficient having values dependent on the ratio of $\frac{A}{B}$ and is to be calculated as follows:—

$$K = 3\left[\frac{A}{B} - \left(\frac{A}{B}\right)^2 - \frac{1}{6}\right]$$

NOTE.—K as calculated may be $\pm$ but the numerical value only is to be taken for use in formula 2.

A = distance between centre line of tube holes or hand holes and the nearest supporting side, in inches ; where there are more than one row of tube holes in the length B, the value of A which gives a maximum K is to be selected.

Cross-reference

1610 For details of hand holes and doors, *see* J 1405 to J 1407.

For details of tube holes and fitting of tubes, *see* J 1507–J 1508.

Tubes

1611 The minimum thickness of tubes is to be determined by the following formulæ :—

For all boiler and economiser tubes :—

$$t = \frac{WP \times d}{10 \times S} + 1{\cdot}5\,d + 4$$

For superheater tubes :—

$$t = \frac{WP \times d}{K} + 6$$

where WP = working pressure in the boiler, in lb. per square inch,
d = external diameter, in inches,
S = minimum tensile strength of the tube material, in tons per square inch,
t = thickness, in 100ths of an inch.

K is a coefficient given in Table 2.

TABLE 2

COEFFICIENT K

TUBE MATERIAL		METAL TEMPERATURE °F.								
TYPE OF STEEL	Minimum tensile strength tons per sq. inch	650	700	750	800	850	900	950	1000	1050
Carbon steel ...	20	200	192	180	160	136	110			
Carbon steel ...	28	280	260	240	200	160	110			
0·5% Molybdenum Alloy Steel	25	250	250	250	250	250	220	160	90	
1% Chromium, 0·5% Molybdenum Alloy Steel	25	250	250	250	250	250	230	200	140	90

The estimated metal temperature of the superheater tubes is to be stated when plans are submitted for approval but in no case is a temperature less than the maximum steam temperature plus 50°F. to be taken when evaluating K. For temperatures intermediate between those listed in the table and for carbon steels with tensile strengths intermediate between 20 and 28 tons per square inch, the values of K may be obtained by interpolation.

The thicknesses derived from these formulæ are minima and further provision is to be made for minus tolerances where necessary.

Where it is proposed to use other alloy steels for superheater tubes, particulars are to be submitted for special consideration in accordance with J 1402.

The formula for boiler tubes does not provide for adverse corrosion conditions and boiler tubes intended for low pressure boilers of 250 lb. per square inch working pressure and under with open feed systems are to be made one gauge thicker than required by the formula.

1612 The thickness of downcomer tubes and pipes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the Rules for steam pipes.

Standpipes

1613 Where standpipes and branches are attached to drums or headers by means of welding or by screwing and seal welding the minimum wall thickness for metal temperatures up to 650° F. is to be determined by the following formula but in no case is to be less than $\frac{1}{4}$ inch:—

$$t = 1{\cdot}4D + 6$$

where t = thickness of standpipe or branch, in 32nds of an inch,

D = nominal bore, in inches.

For metal temperatures above 650° F. the wall thickness is to be not less than that required by the above formula or by the formula for shells in 1602, whichever is the greater.

1614 Every flange is to have a fillet with a radius not less than the thickness of the neck to which it is attached.

Section 17

BOILER MOUNTINGS AND FITTINGS FOR WATER TUBE BOILERS

Safety Valves

1701 The safety valves in number, area and design are to be in accordance with the requirements of J 403 to J 411, and are to be so disposed and proportioned that the superheater will be protected from overheating in all normal circumstances.

Waste Steam Pipe

1702 The waste steam pipe and passages leading to it from the safety valves are to be in accordance with the requirements of J 411.

Safety Valve Settings

1703 All boiler and superheater safety valves are to be set under steam to their respective working pressures which are to be not greater than 3 per cent above the pressure for which the boiler is approved. In the setting of superheater safety valves, allowance is to be made for the pressure drop through the superheater so that under discharge conditions the pressure in the boiler will not exceed the approved boiler pressure.

In no case shall the superheater safety valve setting exceed by more than 3 per cent the pressure for which the steam piping and shafting are approved.

Accumulation Tests

1704 Tests for accumulation of pressure are to be carried out with the stop valve closed and under full firing conditions for a period not exceeding 7 minutes. The accumulation is not to exceed 10 per cent of the working pressure.

Where accumulation tests might endanger the superheaters, consideration will be given in cases of oil fired boilers to the omission of these tests, provided that application is made when the boiler plan and sizes of safety valves are submitted for approval, and that the safety valves are of an approved type for which the capacity has been established by test in the presence of the Surveyors or an approved independent authority, or for which the Society is satisfied, by long experience of accumulation tests, that the capacity is adequate.

When it is agreed to waive accumulation tests it will be required that the valve makers provide a certificate for each safety valve, stating its rated capacity at the approved working conditions of the boilers and that the boiler makers provide a certificate for each boiler stating its maximum evaporation.

The safety valves are to be found satisfactory in operation under working conditions during the trials of the machinery on board ship.

Stop Valves

1705 Where two or more boilers are connected together, stop valves of self-closing or non-return types are to be fitted.

Water Level Indicators

1706 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass water gauge.

The other means is to be either an additional glass water gauge or an approved equivalent device other than test cocks, but where a steam and water drum exceeding 13 feet in length is fitted athwartships, two glass water gauges are to be fitted in suitable positions, one near each end of the drum.

1707 The position of the glass water gauges of boilers in which the tubes are entirely drowned when cold is to be such that water is just showing in the glass when the water level in the steam drum is just above the top of the uppermost tubes when the boiler is cold. In boilers, the tubes of which are not entirely drowned when cold, the glass water gauges are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

Feed Check Valves and Water Level Regulators

1708 Each boiler is to be provided with a main feed check valve and an auxiliary feed check valve, which are to be attached, wherever practicable, direct to the boiler or to an economiser which forms an integral part of the boiler.

Where, however, the arrangements necessitate the use of a common inlet pipe on the economiser for both main and auxiliary feed systems, this pipe is to be as short as practicable and the arrangement of check valves is to be such that either feed line can be effectively isolated without interruption of the feed water supply to the boiler.

At least one of the feed water systems is to be fitted with an approved feed water regulator whereby the water level in the boilers is controlled automatically. (*See* E 7 for arrangements and details of boiler feed systems.)

1709 The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

1710 Standpipes on boilers, for feed inlets, are to be designed with an internal pipe to prevent direct contact between the feed pipe and the boiler shell or end plates with the object of minimizing thermal stresses in these plates.

Similar arrangements are to be provided for desuperheater and other connections where significant temperature differences occur in service.

Mountings and Fittings

1711 Mountings and fittings not mentioned in this Section are to be in accordance with the requirements of J 4.

WELDED PRESSURE VESSELS

Notes:—The following rules relate to welded pressure vessels of thickness not less than $\frac{3}{16}$ inch and operating at temperatures not exceeding 650° F. Vessels intended for higher temperatures than 650° F. may be constructed in accordance with these rules, with the exception that the scantlings and routine tests required will be subject to special consideration when the plans are submitted for approval.

For list of manufacturers of Class 1 Welded Pressure Vessels see appendix to this Chapter.

Section 18

GENERAL REQUIREMENTS

Definitions

1801 The term "**fusion weld**" is, for the purposes of these Rules, applicable to all welded joints made by the oxy-acetylene or the oxy-hydrogen process, the metal-arc process with covered electrodes, or other electric arc process in which the arc stream and the deposited weld metal are shielded from atmospheric contamination.

1802 The term "**forge weld**" is, for the purposes of these Rules, applicable to joints made between plates which are welded together by means of hammering or rolling, and in which no added metal is included.

Quality of Material

1803 The material used in the construction of welded pressure vessels is to be in accordance with the requirements of P 1 and P 5.

Construction

1804 In all cases, before construction is commenced, plans are to be submitted showing full details of the welding and giving particulars of the size and type of electrodes, also the ultimate tensile strength of the materials proposed to be used in the construction of the pressure vessel.

1805 In order to facilitate consideration when classifying pressure vessels in accordance with 1820 to 1822, and especially in cases in which there may appear to be some doubt regarding the class under which a vessel may be considered, particulars of the service conditions for which the vessel is intended should also be submitted.

Cylindrical Shells

1806 For the cylindrical shells of welded steel pressure vessels, the maximum working pressure to be allowed is to be calculated from the following formula :—

$$WP = \frac{f(t-2)}{16 \times D}$$

where WP = working pressure, in lb. per square inch,

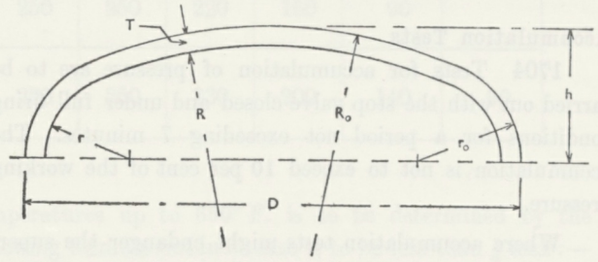
f = maximum permissible stress in the longitudinal joint, in lb. per square inch, as given in Table 3 for fusion welded pressure vessels and J 23, Table 4, for forge welded pressure vessels

t = thickness of the shell plates, in 32nds of an inch,

D = internal diameter of the cylindrical shell, in inches.

Dished End Plates without Stays

1807 For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates intended for Class 1 pressure vessels and dished to partially spherical form, subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the working pressure to be allowed is to be determined by one of the following formulæ:—



$$WP = \frac{4726 \times S \times h}{D^2} \left\{ \frac{\frac{r}{R} + \cdot 05}{\frac{r}{R} + \cdot 15} \right\} \times (T - \cdot 03)$$

$$WP = \frac{480 \times S\,(T - \cdot 03)}{R}$$

For end plates of similar type intended for Class 2 or Class 3 pressure vessels, the required thickness may be determined by the following formula :—

$$WP = \frac{576 \times S \times T}{R}$$

where WP = working pressure, in lb. per square inch,

T = thickness of the end, in inches, after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material,

S = minimum tensile strength of the material, in tons per square inch,

D = outside diameter of drum end, in inches,

R = inside radius of curvature of end, in inches, which is not to exceed D,

r = inside corner radius, in inches,

h = external height of dishing, in inches, measured from the centre of the inside corner radius and may be determined as follows :—

$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)}$$

TABLE 3

MAXIMUM PERMISSIBLE STRESSES IN THE LONGITUDINAL JOINTS OF FUSION WELDED PRESSURE VESSELS, FOR TEMPERATURES NOT EXCEEDING 650° F.

Conditions in respect of routine tests and heat treatment.	Maximum permissible stress 'f', in lb. per square inch, to be used in Formula given in 1806.					
	Minimum tensile strength of plate :— 26 tons per square inch			Minimum tensile strength of plate :— 28 tons per square inch		
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
Vessels made by approved manufacturers only and subject to routine tests prescribed in J 1907 to J 1919 and including complete X-ray examination, heat treatment and hydraulic test.	13,100	—	—	14,100	—	—
Subject to routine tests prescribed in J 2002 to J 2012, and including heat treatment and hydraulic test.	—	A. 11,500	—	—	A. 12,400	—
Subject to routine tests prescribed in J 2002 to J 2012, and hydraulic test but not including heat treatment.	—	B. 10,800	—	—	B. 11,600	—
Subject to routine tests prescribed in J 2102 to J 2113, and including heat treatment and hydraulic test.	—	—	A. 10,000	—	—	A. 10,800
Subject to routine tests prescribed in J 2102 to J 2113, and hydraulic test but not including heat treatment.	—	—	B. 9,300	—	—	B. 10,000
Subject to hydraulic test only.	—	—	C. 8,600	—	—	C. 9,300
Double fillet lap joint for longitudinal shell seams, for shell thickness not exceeding $\frac{3}{8}$ in. Subject to hydraulic test only.	—	—	D. 7,900	—	—	D. 8,500

NOTE : Where the minimum tensile strength of the plate material is other than 26 or 28 tons per square inch, but not more than 35 tons per square inch, the maximum permissible stress should be proportional to the above.

R_0 = outside radius of curvature of the end, in inches,

r_0 = outside corner radius, in inches.

The inside corner radius r is to be not less than four times the thickness of the end plate and in no case less than $2\frac{1}{2}$ inches.

1808 Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

1809 Where the end plates are dished to partially spherical form, subject to pressure on the convex side and not fitted with stays, the following formula is to be used :—

$$WP = \frac{C \times T \times S}{R}$$

where WP = working pressure, in lb. per square inch,

T = thickness of the end plate, in inches,

R = radius of the convex surface of the end plate, in inches, which is not to exceed the diameter of the shell,

S = minimum tensile strength of the material, in tons per square inch,

C = 310 for Class 1 pressure vessels when T does not exceed $\frac{9}{16}$ inch,

340 for Class 1 pressure vessels when T exceeds $\frac{9}{16}$ inch,

370 for Class 2 and Class 3 pressure vessels when T does not exceed $\frac{9}{16}$ inch,

410 for Class 2 and Class 3 pressure vessels when T exceeds $\frac{9}{16}$ inch.

Flat End Plates without Stays

1810 For unstayed flat end plates welded to cylindrical shells either by forge welding or by one of the fusion welded methods shown in Fig. 1,

$$WP = \frac{C \times (t_1 - 1)^2}{D^2}$$

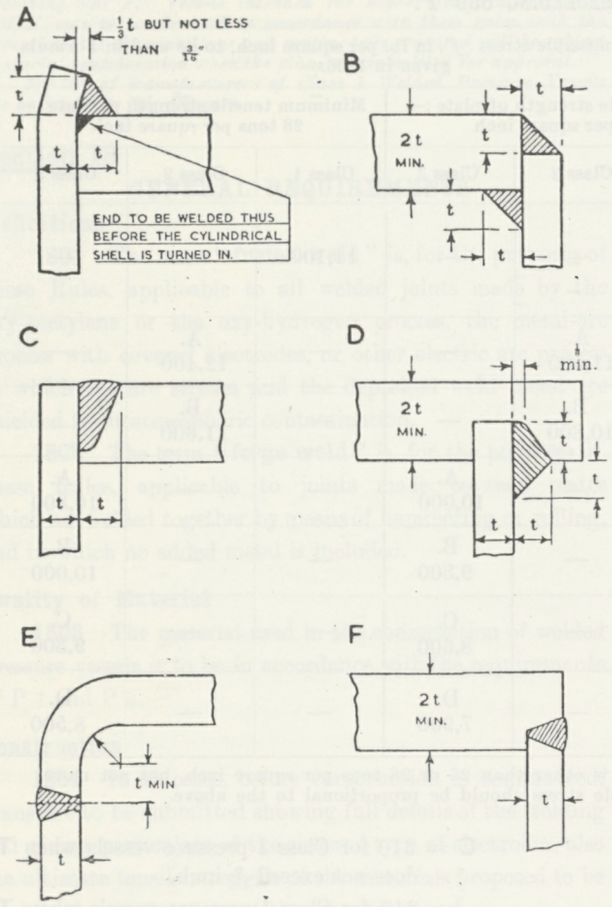
where WP = working pressure, in lb. per square inch,

t_1 = thickness of the end plate, in 32nds of an inch,

D = internal diameter, in inches,

C = 72·5 where end plate is exposed to flame,
100 where end plate is not exposed to flame.

FIG. 1 TYPICAL ACCEPTABLE METHODS OF ATTACHING FLAT END PLATES TO CYLINDRICAL SHELLS.



NOTE:—The proportions indicated for the welds are minima only.

Compensation for Openings

1811 Where a dished end is provided with a flanged manhole the thickness of the end in inches obtained by the formulæ in 1807 and 1809, is to be increased by $\frac{1}{8}$ inch, and the depth (F) of the manhole flange, measured in inches from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in inches,

W = minor axis of the manhole, in inches.

1812 Where a dished end is provided with large openings for branches, mountings or unflanged manholes, the thickness of the end as determined by the formulæ in 1807 and 1809, is to be increased by $\frac{1}{8}$ inch and adequate compensation is to be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1813 Where a dished end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

1814 Where a flat plate is flanged for stiffening it at a manhole or sighthole, the total depth of the flange measured in inches from the outer surface is to be at least equal to $\sqrt{T \times W}$, where T is the thickness of the plate in inches and W is the minor axis of the hole in inches.

1815 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided in accordance with 1816.

1816 Compensation is to be provided for all openings in shell plates if the diameters of such openings exceed 2·5 times the thickness of the shell plus $2\frac{3}{4}$ inches.

The total area of compensation to be provided is to be not less than the sectional area of the plate cut out to form the opening multiplied by the ratio :—

$$\frac{\text{Permissible stress in welded joint in lb. per sq. in.}}{560 \times \text{min}^{m} \text{ tensile strength of shell plate in tons per sq. in.}}$$

The sectional area cut out is to be based on the thickness of a seamless shell and measured on the centre line of the opening parallel with the longitudinal axis of the shell, and the area of compensation provided is to be measured in the same plane as the sectional area cut out, and may include the sectional area of the welds by which the compensating plate or branch piece may be attached.

In cases where branch pieces are welded to the shell or end plate, the maximum height of the branch body to be reckoned as compensating for the sectional area cut out is to be obtained thus :—

$$H = 1{\cdot}2\ \sqrt{D \times T}$$

where H = height, in inches, measured from the inside surface of the shell or end plate,

D = diameter or longitudinal axis, in inches, of the opening cut in the plate,

T = thickness, in inches, of the shell or end plate.

If the height of the branch obtained by this formula, in conjunction with its thickness, is inadequate to compensate for the sectional area cut out, additional compensation is to be provided.

Attachment of Compensating Plates, Branches, etc.

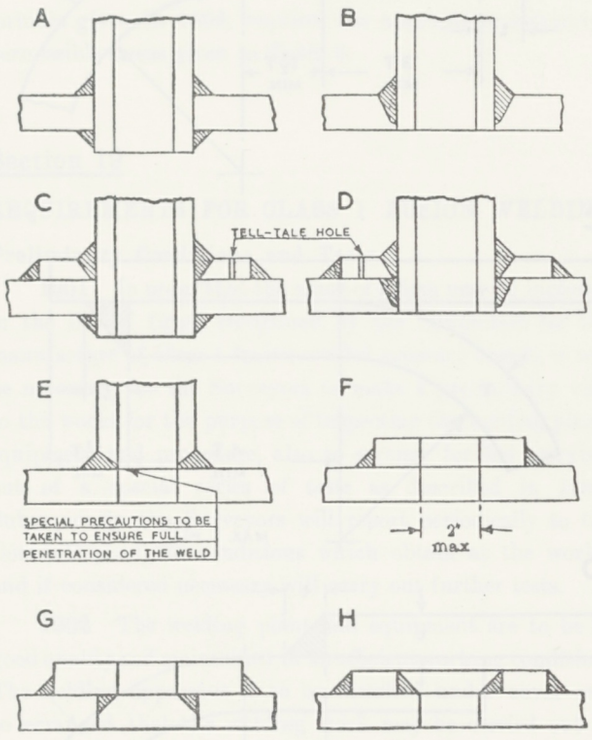
1817 All welded compensating plates, branch pieces and bosses may be secured by one of the methods shown in Fig. 2.

Compensating plates attached to the outside of a vessel as in Fig. 2 types C and D are to be provided with a tell-tale hole not greater than $\frac{3}{8}$ inch diameter. The tell-tale hole is to be left open to the atmosphere.

In the case of compensating plates attached to the inside of a vessel the tell-tale hole is to be drilled in the shell.

Flanges may be attached to carbon steel branch pieces by any of the methods shown in Fig. 3. If backing rings are used with flange type A they are to fit closely to the bore of the pipe and are to be of good quality mild steel.

FIG. 2 TYPICAL ACCEPTABLE METHODS OF ATTACHING BRANCHES, COMPENSATING RINGS AND BOSSES.



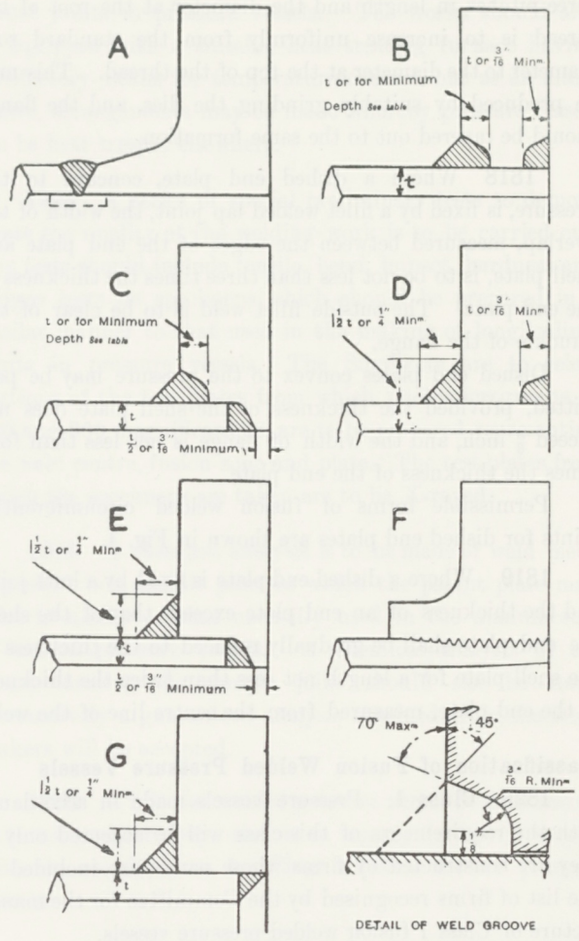
NOTE:—Type E should be used for the attachment of heavy branches to relatively thick shells.

Alternative methods of attachment may be accepted provided details are submitted for consideration.

Where flanges are secured by screwing, the branch and flange are to be screwed with a vanishing thread, and the diameter of the screwed portion of the branch over the thread is to be not less than the outside diameter of the unscrewed branch.

After the flange has been screwed hard home the branch is to be expanded into the flange.

FIG. 3 ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL BRANCHES OR STANDPIPES.



Pipe Bore	Minimum Depth of Groove for flanges B and C
$\frac{1}{2}$" and $\frac{3}{4}$"	$\frac{1}{4}$"
1" to 1$\frac{1}{2}$"	$\frac{5}{16}$"
2" and over	$\frac{3}{8}$"

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure lb. per sq. in.	Temperature °F.	Pressure lb. per sq. in.	Temperature °F.
A, B & C	All Conditions			
D & E	750	500	500	750
F	600		450	
G	250		250	500

The vanishing thread on a branch is to be not less than three pitches in length and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

1818 Where a dished end plate, concave to the pressure, is fixed by a fillet welded lap joint, the width of the overlap, measured between the edges of the end plate and shell plate, is to be not less than three times the thickness of the end plate. The outside fillet weld is to be clear of the knuckle of the flange.

Dished end plates convex to the pressure may be permitted, provided the thickness of the shell plate does not exceed $\frac{5}{8}$ inch, and the width of flange is not less than four times the thickness of the end plate.

Permissible forms of fusion welded circumferential joints for dished end plates are shown in Fig. 4.

1819 Where a dished end plate is fixed by a butt joint and the thickness of an end plate exceeds that of the shell, the end plate shall be gradually reduced to the thickness of the shell plate for a length not less than twice the thickness of the end plate, measured from the centre line of the weld.

Classification of Fusion Welded Pressure Vessels

1820 Class 1. Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 fusion welded pressure vessels.

Class 1 includes all fired and unfired pressure vessels for which the calculated working pressure on the shell, according to the formula given in 1806, requires the appropriate maximum permissible stress given in Table 3. For Class 1 pressure vessels intended for water tube boilers the scantlings are to be determined by the requirements of J 16.

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with Class 1 requirements:—

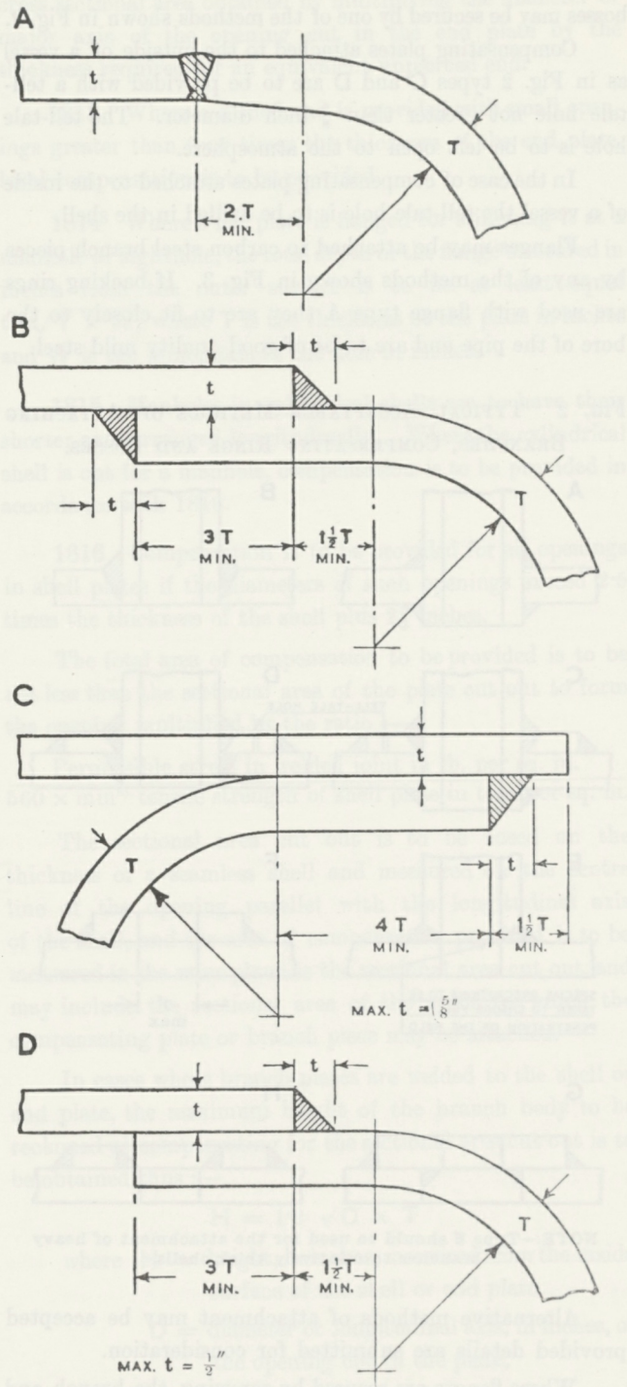
Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 50 lb. per square inch.

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

1821 Class 2. Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with Class 2 requirements:—

Fired pressure vessels intended for a working pressure not exceeding 50 lb. per square inch.

FIG. 4 TYPICAL ACCEPTABLE METHODS OF ATTACHING DISHED ENDS TO CYLINDRICAL SHELLS.



Type	Acceptable for
A	Class 1, 2 & 3
B	„ 2 & 3
C	„ 2 & 3
D	„ 3

Pressure vessels requiring the appropriate maximum permissible stress given in Table 3.

Unfired pressure vessels for which WP × T is greater than 90, where WP = proposed working pressure, in lb. per square inch, T = actual thickness of the shell plate, in inches.

Unfired pressure vessels for which the working pressure is greater than 250 lb. per square inch.

Unfired pressure vessels for which the working temperature of the contents is greater than 300° F.

Unfired pressure vessels of shell thickness greater than $\frac{5}{8}$ inch.

1822 Class 3. This class includes all unfired pressure vessels not included in Class 1 or Class 2 for which the calculated working pressure on the shell, according to the formula given in 1806, requires the appropriate maximum permissible stress given in Table 3.

Section 19

REQUIREMENTS FOR CLASS 1 FUSION WELDING

Preliminary Conditions and Tests

1901 In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 fusion welded pressure vessels, it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in 1904. Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

1902 The welding plant and equipment are to be of good quality and maintained in an efficient working condition. The welding apparatus is to be installed under cover and so arranged that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work, and the welding operators are to be subjected by the works officials to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available to the Surveyors for inspection.

1903 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, micro-examination of specimens and X-ray examination of the actual joints in pressure vessels. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

1904 A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre, fusion zone and plate. The test plates from which the specimens are taken are to be X-rayed.

1905 A chemical analysis is to be made of weld metal deposited in a sample joint in which the parent plate material is similar to that normally used in the manufacture of welded pressure vessels. A chemical analysis of the plates forming the sample joint should also be made, alternatively a guaranteed analysis obtained from the steelmakers will be accepted.

1906 A full size welded pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 fusion welded pressure vessels.

Routine Tests for Class 1 Fusion Welded Pressure Vessels

1907 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported, during welding, that warping is reduced to a minimum.

1908 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

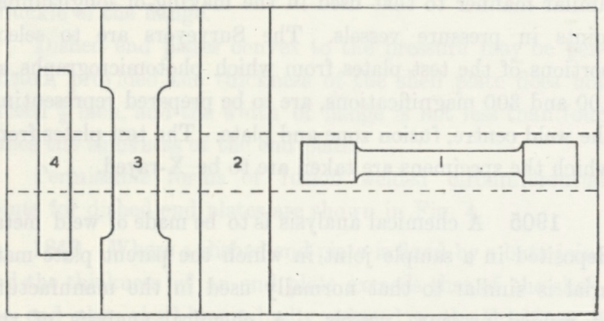
1909 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, when two test plates are to be prepared, each having a welded joint which, so far as possible, is a duplication of the circumferential seams.

1910 The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

1911 The thickness of test plates is to be the same as that of the pressure vessel.

1912 One test plate is to be cut up into test specimens as shown in Fig. 5. All the specimens are to be cut from a plate of suitable length and are to comply with the test requirements detailed in 1914 to 1918.

FIG. 5



(1) Tensile, all weld metal. (3) Tensile (joint).
(2) Bend. (4) Macro.

Retests

1913 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test for all Weld Metal. Specimen No. 1

1914

Diameter of test piece inches	Gauge length inches
·798	2·82
·564	2·0
·505	1·79
·479	1·70
·452	1·60
·437	1·55
·424	1·50
·399	1·41
·357	1·26

The ultimate tensile strength of weld metal is to be not less than the minimum specified for the plate.

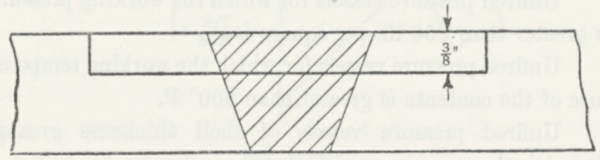
Minimum elongation on gauge length = 20 per cent.

Minimum reduction of area = 35 per cent.

Bend Test. Specimen No. 2

1915 Dimensions of specimen = $\frac{3}{4}$ inch wide × $\frac{3}{8}$ inch thick, cut flush with the upper surface of the plate as shown in Fig. 6.

FIG. 6



The specimen is to be bent cold through an angle of 180 degrees, with the broad side of the weld forming the outside of the bend, until the distance between the parallel sides is not greater than $\frac{3}{8}$ inch. The sharp edges of the specimen may be rounded off before bending.

Alternative Bend Test

1916 Two bend test specimens of rectangular section are to be cut from the test plate, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension.

The specimens are to be cut transversely to the weld and are to have a width equal to 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. The edges may be rounded off to a radius not exceeding 10 per cent of the thickness of the specimen.

In plate thicknesses not exceeding $1\frac{1}{4}$ inches, the thickness of the specimens should be equal to the thickness of the test plate. Where the plate thickness exceeds $1\frac{1}{4}$ inches, the specimens should, in all cases, have a thickness of $1\frac{1}{4}$ inches, and width of $1\frac{7}{8}$ inches. These should be prepared by discarding metal from the surfaces of the specimens which will be in compression when the test is applied. *See* Figs. 7 and 8.

Where the thickness of the plate permits, the bend specimens may be prepared as shown in Fig. 9.

For each specimen the weld reinforcement should be removed by buffing or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate.

Each specimen is to be bent cold without fracture through an angle of 180 degrees, over a former having diameter not greater than three times the thickness of the specimen. The distance between supports should be not more than 5·2 times the thickness of the specimen.

FIG. 7 NORMAL BEND SPECIMEN

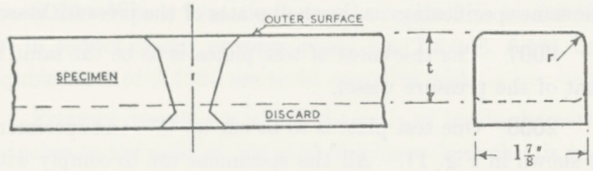


FIG. 8 REVERSE BEND SPECIMEN

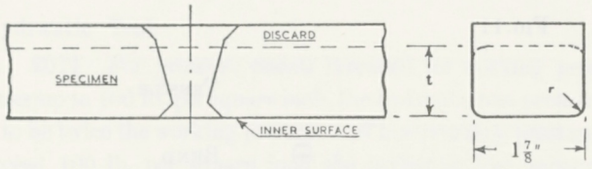
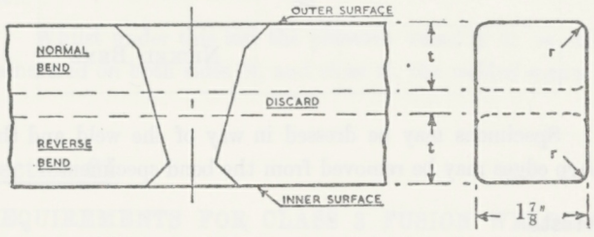


FIG. 9 NORMAL AND REVERSE BEND SPECIMENS CUT FROM SINGLE PIECE OF PLATE



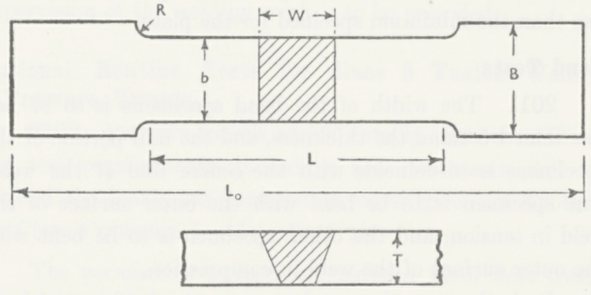
t = thickness of the specimen which is the thickness of the plate or $1\frac{1}{4}$ inches, whichever is the lesser.

r = corner radii not exceeding ·1t.

NOTE:—Where t is less than $1\frac{1}{4}$ inches the width of the specimen is to be 1·5t.

Tensile Test for Joint. Specimen No. 3

1917 FIG. 10



When T is less than 1 inch:—

L_o = 10 inches.

L = W + $\frac{1}{2}$ inch. R = $\frac{3}{16}$ inch.

B = $1\frac{1}{4}$ inches.

b = $\frac{7}{8}$ inch.

When T is greater than 1 inch:—

L_o = 12 inches.

L = W + $\frac{1}{2}$ inch. R = $\frac{1}{4}$ inch.

B = $1\frac{1}{2}$ inches.

b = 1 inch.

An equivalent form of test piece to the above may be accepted.

The weld is to be machined flush with plates on both sides.

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

Macro Specimen. Specimen No. 4

1918 The specimen is to be etched across the full section of the weld, and examined by the Surveyor.

X-ray Examination

1919 X-ray photographs are to be taken of the entire length of each welded seam, both longitudinal and circumferential. The surface of the weld is to be dressed smooth by grinding, chipping and grinding, machining or other suitable means, to the satisfaction of the Surveyor, for the purpose of radiography. The photographs are to be marked in such a way that the corresponding portion of the welded seam can readily be identified. The negatives are to be examined by the Surveyor who will indicate whether any rewelding is necessary.

On completion of the rewelding, the affected portions of the seams are to be X-rayed.

X-ray methods employed are to be sufficiently accurate to reveal a defect having a quantitative thickness equal to 2 per cent of the depth of the weld, and on each negative there is to be an indication of the relative shadow density corresponding to 2 per cent of the depth of the weld.

Heat Treatment

1920 Each pressure vessel is to be efficiently heat treated on completion of the welding and before the hydraulic test is carried out.

The heat treatment given to any pressure vessel may be either:—

Normalising, in which the pressure vessel is heated uniformly to a temperature of 920° C. and allowed to cool slowly in still air; or

Stress Relieving, in which the pressure vessel is heated uniformly to a temperature between 600° C. and 650° C., and allowed to cool slowly in still air.

Hydraulic Test

1921 For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Modification of Requirements

1922 In the case of firms of large experience some modification may be permitted in regard to the requirements of 1901 to 1906 and to the requirements relating to Routine Tests for Class 1 fusion welded pressure vessels.

Section 20

REQUIREMENTS FOR CLASS 2 FUSION WELDING

Preliminary Conditions

2001 The welding of Class 2 pressure vessels is to be done only by firms who satisfy the Committee that their works are properly equipped for the welding of pressure vessels.

The welding plant is to be installed under cover and is to be maintained in an efficient working condition and adequate supervision of the welding work is to be provided.

Routine Tests for Class 2 Fusion Welded Pressure Vessels

2002 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

2003 In cases where a number of Class 2 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than $\frac{3}{16}$ inch, each 120 feet of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

2004 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

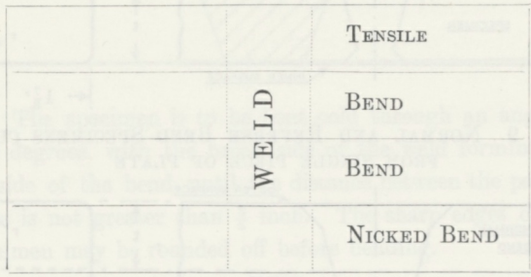
2005 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, when two test plates are to be prepared each having a welded joint which, so far as possible, is a duplication of the circumferential seams.

2006 The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

2007 The thickness of test plates is to be the same as that of the pressure vessel.

2008 One test plate is to be cut up into test specimens as shown in Fig. 11. All the specimens are to comply with the test requirements detailed in 2010 to 2012.

FIG. 11



Specimens may be dressed in way of the weld and the sharp edges may be removed from the bend specimens.

Retests

2009 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test

2010 The shape of the specimen is to conform to the requirements of J 1917.

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

Bend Tests

2011 The width of the bend specimens is to be not less than 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. One specimen is to be bent with the outer surface of the weld in tension, and the other specimen is to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through an angle of 180 degrees over a former, the diameter of which is not greater than three times the thickness of the specimen.

Nicked Bend Test

2012 The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystallinity.

Heat Treatment

2013 Where heat treatment is required to be carried out in respect of any pressure vessel (*see* Table 3, J 18), the requirements of J 1920 are to be complied with.

Pressure vessels for which the ratio of inside diameter in inches to the cube of the shell thickness in inches is less than 100 are to be efficiently heat treated.

Hydraulic Test

2014 For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 21

REQUIREMENTS FOR CLASS 3 FUSION WELDING

Preliminary Conditions

2101 The welding of Class 3 pressure vessels is to be done only by firms who satisfy the Committee that their works are properly equipped for the welding of pressure vessels.

The welding plant is to be installed under cover and is to be maintained in efficient working condition and adequate supervision of the welding work is to be provided.

Optional Routine Tests for Class 3 Fusion Welded Pressure Vessels

2102 Pressure vessels which comply with the following test requirements, including heat treatment, will be allowed the maximum permissible stress given in Table 3 for Class 3 pressure vessels. *See* J 18.

The permissible stresses are reduced when heat treatment and routine tests are omitted. (*See* Table 3.)

In the case of pressure vessels having a shell plate thickness not exceeding $\frac{3}{8}$ inch, double fillet lap joints for the longitudinal seams will be permitted in conjunction with a maximum permissible stress as given in Table 3. In this case heat treatment and routine tests may be omitted.

2103 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

2104 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

2105 The material for the test plates is to conform to the same specification as the shell plates of the pressure vessel.

2106 The thickness of test plates is to be the same as that of the pressure vessel.

2107 One test plate is to be cut up to provide one tensile, one bend and one nicked bend specimen.

2108 In cases where a number of Class 3 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than $\frac{3}{16}$ inch, each 120 feet of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases, the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

2109 Test plates are not required in the case of pressure vessels having circumferential welded seams only.

Retests

2110 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test

2111 The shape of the specimen is to conform to the requirements of J 1917.

The ultimate tensile strength of the joint is to be not less than 95 per cent of the minimum specified for the plate.

Bend Test

2112 The width of the bend specimen is to be not less than 1·5 times the thickness, and the mid portion of the specimen is to coincide with the centre line of the weld. The specimen is to be bent without fracture with the outer surface of the weld in tension, through an angle of 160 degrees over a former the diameter of which is not greater than three times the thickness of the specimen.

Nicked Bend Test

2113 The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystallinity.

Heat Treatment

2114 Class 3 pressure vessels may be required to be heat treated, depending upon the details of design and the service for which the pressure vessels are intended.

Where heat treatment is required to be carried out on any pressure vessel, the requirements of J 1920 are to be complied with.

Hydraulic Test

2115 For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 22

INSPECTION OF FUSION WELDED PRESSURE VESSELS

Note:—The following requirements are applicable to all classes of fusion welded pressure vessels.

Electrodes

2201 In the case of pressure vessels welded by the electric metallic arc process, the electrodes are to be of a type conforming to the terms of the definition for fusion welds given in J 1801.

2202 Electrodes intended for use in the construction of pressure vessels are to be stored in a dry place. In order to ensure that the quality of the electrodes is being consistently maintained they are to be subjected to a regular system of periodic testing and inspection. Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of this paragraph.

2203 In cases in which it is proposed to use electrodes of larger size than $\frac{3}{8}$ inch diameter, full particulars are to be submitted for consideration.

Heat Treatment

2204 The heat treatment of pressure vessels is to be carried out by placing the pressure vessels in a properly constructed furnace having satisfactory means of temperature control.

2205 Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections provided sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

2206 Test plates should be heat treated in the same furnace and at the same time as the pressure vessels which they represent. In special cases, however, it may be permissible to heat treat the test plates separately from the pressure vessels provided the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test plates:—

Rate of heating.

Maximum temperature.

Time held at maximum temperature.

Conditions of cooling.

2207 Where a number of test plates are heated together in a furnace, care is to be taken to ensure that each plate is uniformly exposed to the heat of the furnace.

2208 Where it is proposed to adopt special methods of heat treatment full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

Welding Technique

2209 Welding may be carried out by hand or by machine, and the current used in electric metallic arc welding may be direct or alternating. In welding branch pieces, pads and compensating rings, more than one run of weld metal is to be deposited. Longitudinal and circumferential seams may be reinforced by additional runs of weld metal.

2210 The outer surfaces of the welds may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the centre of the weld is greater than the thickness of the plates, provided the change of section is gradual and there is no undercutting at the sides of the weld.

2211 Each run of weld metal is to be thoroughly cleaned and free from slag before the next run is deposited.

2212 In all Class 1 pressure vessels, the longitudinal and circumferential seams are to be welded from both sides of the plate. In the case of Class 2 and Class 3 pressure vessels which are too small to permit welding from the inside, special care should be taken to ensure full penetration of the first run of weld metal. In such cases it is recommended that a backing strip be provided on the underside of the joint. In order to satisfy himself regarding the penetration, the Surveyor may, if he considers it necessary, request that a sample joint be welded and cut open for his inspection.

2213 The welding of pressure vessels is to be carried out in the downhand horizontal position. In the case of circumferential seams means are to be adopted to ensure compliance with this requirement.

2214 In cases where it is proposed to adopt fusion welding processes in which it may not be possible to comply fully with the foregoing requirements regarding technique, full particulars are to be submitted for consideration.

Fabrication

2215 Before welding, the assembly is to be examined. The shape and size of the joints are to be in accordance with the approved design. The butting edges of the plates forming the longitudinal and circumferential seams are to be in line within a limit of 10 per cent of the plate thickness, but in no case exceeding $\frac{1}{8}$ inch for longitudinal joints and $\frac{3}{16}$ inch for circumferential joints.

2216 The attachment of branches should be examined before and after welding.

2217 During fabrication, the Surveyor is to be provided with opportunities for seeing the actual deposition of weld metal. The joints are to be examined at various stages during construction.

2218 On completion of the welding, the seams are to be thoroughly examined before being dressed or machined. Parts showing evidence of blow-holes, slag inclusions, unsatisfactory penetration, porosity, or any other defect, are to be cut out and rewelded, and excessive undercutting made good.

2219 Each pressure vessel is to be calibrated for distortion. The calibration is to be made after the heat treatment has been carried out. The drum or shell is to be circular at any section within a limit of one per cent of the designed internal diameter based on the difference between the maximum and minimum diameters of any section. Any departure from circularity is to be gradual and there is to be no local flat in way of the welded seam.

Section 23

FORGE WELDED PRESSURE VESSELS

Classification of Forge Welded Pressure Vessels

2301 **Class 1.** Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels.

Class 1 includes all unfired pressure vessels for which the calculated working pressure of the shell, according to the formula given in J 1806, requires the appropriate maximum permissible stress as given in Table 4. For Class 1 fired pressure vessels the scantlings are to be determined by the requirements of J 16.

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with Class 1 requirements :—

Pressure parts of boilers, and all fired pressure vessels intended for working pressures above 50 lb. per square inch.

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

2302 **Class 2.** This class includes all forge welded pressure vessels not included in Class 1. The working pressure of the shell is to be calculated from the formula shown in J 1806, the appropriate maximum permissible stresses being as given in Table 4.

Preliminary Conditions and Tests for Class 1 Forge Welding

2303 In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels, it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in 2306. Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

TABLE 4

Maximum Permissible Stresses in the Longitudinal Joints of Forge Welded Pressure Vessels, for Temperatures not Exceeding 650° F.

Conditions in respect of routine tests and heat treatment.		Maximum permissible stress 'f,' in lb. per square inch, to be used in Formula given in J 1806.			
		Minimum tensile strength of plate :— 24 tons per square inch		Minimum tensile strength of plate :— 26 tons per square inch	
		Class 1	Class 2	Class 1	Class 2
Vessels made by approved manufacturers only and subject to routine tests prescribed in J 2309 to J 2313.	Unfired vessels	11,200	—	12,200	—
Vessels not included in the above category.	Shell thickness $\frac{5}{8}$ inch and above.	—	9,900	—	10,800
	Shell thickness less than $\frac{5}{8}$ inch.	—	9,200	—	10,000

Note : Where the minimum tensile strength of the plate material is other than 24 or 26 tons per square inch, but not more than 30 tons per square inch, the maximum permissible stress should be proportional to the above.

2304 The welding plant and equipment are to be of good quality and maintained in efficient working condition. The welding plant is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The procedure is to be such that there is regular and systematic supervision of the welding work.

2305 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, and micro-examination. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

2306 A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre and the plate remote from the weld.

2307 A full size pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 forge welded pressure vessels.

2308 In the case of firms of large experience some modification may be permitted in regard to the requirements of 2306, provided satisfactory evidence is produced of successful results obtained by the firm's welding methods, over an appreciable period.

Routine Tests for Forge Welded Pressure Vessels

Class 1

2309 The shell plates of each pressure vessel are to be left long enough to accommodate the following test specimens :—

Two tensile specimens, } with provision
Four bend specimens, } for retests.

Retests

2310 If any of the tests fail, two retests are to be made, both of which are to comply fully with the test requirements.

Tensile Test

2311 The tensile specimens are to conform to the standard test piece A (*see* P 203), and the mid portion of the specimens is to coincide with the centre line of the weld.

The ultimate tensile strength of both test pieces is to be not less than 95 per cent of the minimum specified for the plate material. The elongation is to be not less than 18 per cent on a gauge length of 8 inches.

Bend Tests

2312 The width of the bend specimens is to be not less than 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld.

Two specimens are to be bent in such a manner that the outer surface of the weld is in tension, and two specimens are to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180 degrees round a former, the diameter of which is not greater than three times the thickness of the specimen.

NOTE :—Some modification of the requirements contained in 2309 to 2311 may be permitted in circumstances such as are indicated in 2308.

Test Pieces for Circumferential Seams

2313 In the case of pressure vessels having circumferential joints only, no test pieces need be provided unless the internal diameter of the pressure vessel exceeds 4 feet 6 inches, when a representative welded joint is to be made and cut up to provide the specimens detailed above.

Class 2

2314 In the case of forge welded pressure vessels other than those included in Class 1, routine tests are not required in respect of longitudinal joints, but where the internal diameter of a pressure vessel exceeds 4 feet 6 inches the manufacturer is to produce authoritative evidence of test results demonstrating that efficient circumferential welds of the proposed dimensions can be made consistently.

GENERAL REQUIREMENTS

Plate Thickness

2315 In the case of all pressure vessels the thickness of the shell plate is to be not less than $\frac{1}{4}$ inch.

Weld Thickness

2316 On completion of the welding the thickness at and adjacent to the weld is to be not less than the required thickness of the shell plate as determined from the formulæ for working pressure given in J 1602, J 1603 and J 1806.

Heating

2317 The heating of plates for welding is to be carried out by means of a process which will provide a flame which will not be of an oxidizing character and will not tend to introduce impurities into the steel. Provision is to be made for careful control of the welding heat.

Heat Treatment

2318 All forge welded pressure vessels are to be efficiently normalised in accordance with the requirements of J 1920.

Hydraulic Test

2319 Pressure vessels are to be subjected to a hydraulic test pressure of twice the working pressure. Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 24

AIR RECEIVERS

2401 Cylindrical receivers for containing air under high pressure may be made either of seamless steel or of welded, or riveted, steel plates.

Welded Receivers

2402 Receivers of fusion or forge welded construction are to comply with the requirements of J 18 to J 23.

Riveted Receivers

2403 Receivers of riveted construction are to comply with the Rules for cylindrical boilers, where applicable, but where end plates are dished to partially spherical form, subject to pressure on the concave side, and not fitted with stays, the following formula may be used :—

$$WP = \frac{576 \times S \times T}{R}$$

where WP = working pressure, in lb. per square inch,

S = ultimate tensile strength of the plates, in tons per square inch,

T = thickness of the end, in inches, after dishing,

R = inside radius of curvature of the end, in inches, which is not to exceed the diameter of the shell.

If desired the formula for dished ends detailed in J 1301 may be used in lieu of the above formula.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than $2\frac{1}{2}$ inches.

Where the end is provided with a flanged manhole the thickness of the end, in inches, determined by the foregoing formula is to be increased by $\frac{1}{8}$ inch and the depth (F) of the manhole flange, measured in inches from the outer surface at the minor axis is to be not less than $F = \sqrt{T_1 \times W}$

where T_1 = required thickness of the end plate, in inches,

W = minor axis of the manhole, in inches.

Seamless Receivers

2404 The material used is to comply with the requirements of P 508.

2405 The permissible working pressure for seamless receivers is to be determined by the following formulæ :—

$$WP = \frac{C \times S \times (t - 4)}{D}$$

for thicknesses of $\frac{5}{8}$ inch and above.

$$WP = \frac{C \times S \times (t - 2)}{D}$$

for thicknesses below $\frac{5}{8}$ inch.

where WP = working pressure, in lb. per square inch,

S = minimum tensile strength of the steel shell plates, in tons per square inch,

t = thickness of the shell plates, in 32nds of an inch,

D = internal diameter, in inches,

C = 38·5 for receivers of thickness $\frac{5}{8}$ inch and above,

34·5 for receivers of thickness below $\frac{5}{8}$ inch.

2406 Each seamless receiver is to be carefully annealed after manufacture, and before the hydraulic test.

Hydraulic Test

2407 Each seamless receiver is to be subjected to a hydraulic test of twice the working pressure, which it is to withstand without permanent set.

2408 Each receiver made of riveted steel plates for pressures up to 300 lb. per square inch is to be tested by hydraulic pressure to 1·5 times the working pressure, plus 50 lb. per square inch. Where higher working pressures are used, the test pressure need not be more than 200 lb. per square inch above the working pressure.

General

2409 All receivers above 6 inches internal diameter are to be so made that the internal surfaces may be examined and, wherever practicable, the openings for this purpose are to be sufficiently large for access. Means are to be provided for cleaning the inner surfaces by steam, or otherwise.

2410 Each receiver which can be isolated from a safety valve is to be provided with a suitable fusible plug to discharge the contents in case of fire.

2411 Each receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

Cross-reference

2412 For scantlings of compressed air pipes, *see* E 506 and E 512.

Section 25

PERIODICAL SURVEYS

2501 For periodical survey requirements, *see* Chapter C.

21st April, 1955

APPENDIX

FIRMS RECOGNISED BY THE COMMITTEE FOR THE MANUFACTURE OF CLASS 1 WELDED PRESSURE VESSELS.

Note: The Society's Office giving attendance at the Works is shown in brackets.

FUSION WELDING

United Kingdom

Adamson, Daniel, & Co., Ld., Dukinfield, Cheshire. (MANCHESTER.)

Adamson, Joseph, & Co., Ld., Hyde, Cheshire. (MANCHESTER.)

Ashmore, Benson, Pease & Co., Ld., Parkfield Works, Stockton-on-Tees. (MIDDLESBROUGH.)

Babcock & Wilcox, Ld., Renfrew. (GLASGOW.)

Balfour, Henry, & Co., Ld., Leven, Fife. (LEITH.)

Brown, John, & Co., Ld., Clydebank. (GLASGOW.)

Clarke, Chapman & Co., Ld., Gateshead. (NEWCASTLE.)

Clayton, Son & Co., Ld., Pepper Road, Hunslet, Leeds 10. (LEEDS.)

Cochran & Co. (Annan) Ld., Annan. (GLASGOW.)

Danks, Edwin, & Co. (Oldbury) Ld. (BIRMINGHAM.)

Danks of Netherton Ld., Netherton. (BIRMINGHAM.)

English Electric Co. Ld., Stafford. (BIRMINGHAM.)

F.B. Engineers, Ld., Atlas Works, Sheffield. (SHEFFIELD.)

W. J. Fraser & Co., Ld., Monk Bretton, near Barnsley. (SHEFFIELD.)

Harland & Wolff, Ld., Belfast. (BELFAST.)

Harvey, G. A., & Co. (London), Ld., London, S.E.1. (LONDON.)

Head, Wrightson & Co., Ld., Thornaby-on-Tees. (MIDDLESBROUGH.)

Horseley Bridge & Thomas Piggott, Ld., Tipton, Staffs. (BIRMINGHAM.)

Jenkins, Robert, & Co., Ld., Rotherham. (SHEFFIELD.)

Marshall & Anderson, Ld., Manse Road, Motherwell, Works:—Broomside. (GLASGOW.)

Marshall Sons & Co. Ld., Britannia Works, Gainsborough, Lincs. (NOTTINGHAM.)

Mechans Ld., Scotstoun Iron Works, Glasgow. (GLASGOW.)

Motherwell Bridge & Engineering Co., Ld., Motherwell. (GLASGOW.)

Robey & Co., Ld., Globe Works, Lincoln. (NOTTINGHAM.)

Ruston & Hornsby, Ld., Lincoln. (NOTTINGHAM.)

South Durham Steel & Iron Co., Ld., Stockton-on-Tees. (MIDDLESBROUGH.)

Stephen, Alexander, & Sons, Ld., Glasgow. (GLASGOW.)

Thompson, John (Wolverhampton) Ld., Wolverhampton. (BIRMINGHAM.)

Whessoe, Ld., Darlington. (MIDDLESBROUGH.)

Yarrow & Co., Ld., Scotstoun, Glasgow. (GLASGOW.)

Australia

Babcock & Wilcox of Australia (Pty.) Ltd., Regents Park, N.S.W. (SYDNEY.)

Cockatoo Docks & Engineering Co., Pty., Ld., Sydney, N.S.W. (SYDNEY.)

Commonwealth Ordnance Factory, Maribyrnong, Victoria. (MELBOURNE.)

Smith, Bernard, Pty. Ld., Sydney, N.S.W. (SYDNEY.)

Thompsons (Castlemaine) Ld., Melbourne, Victoria. (MELBOURNE.)

Belgium

Cockerill, John, S.A., Seraing. (ANTWERP.)

Canada

Canadian General Electric Co., Ld. (Canadian Allis-Chalmers, Ld.) Davenport Works, Toronto. (TORONTO.)

Canadian Vickers, Ld., Montreal. (MONTREAL.)

Dominion Bridge Co., Ld., Lachine, Quebec. (MONTREAL.)

Foster Wheeler, Ld., St. Catharines, Ontario. (TORONTO.)

Inglis, John, & Co., Ld., Toronto. (TORONTO.)

Vancouver Iron Works, Ld., Vancouver, B.C. (VANCOUVER.)

Denmark

Aalborg Vaerft A/S., Aalborg. (COPENHAGEN.)

Burmeister & Wain, A/S., Copenhagen. (COPENHAGEN.)

Helsingor Skibsvaerft & Maskinbyggeri, Elsinore. (COPENHAGEN.)

France

Ateliers et Chantiers de la Loire. (NANTES.)

Chantier de Penhöet, St. Nazaire. (NANTES.)

Compagnie de Fives-Lille, Fives-Lille, Nord. (VALENCIENNES.)

Sté. Française des Constructions Babcock and Wilcox, La Courneuve, Seine. (ROUEN.)

Germany

Borsig A.G., Berlin-Tegel. (HANOVER.)

Bremer Vulkan, Bremen-Vegesack. (BREMEN.)

Deutsche Babcock & Wilcox Dampfkesselwerke A.G., Oberhausen. (DUSSELDORF.)

Deutsche Werft A.G., Hamburg. (HAMBURG.)

Guttehoffnungshütte Oberhausen A.G., Werk Sterkrade, Oberhausen-Sterkrade. (DUSSELDORF.)

Howaldtswerke A.G., Kiel. (KIEL.)

Koerver & Lersch, Krefeld. (DUSSELDORF.)

Fried. Krupp, Essen. (DUSSELDORF.)

Mannesmann Hüttenwerke A. G., Duisburg-Huckingen. (DUSSELDORF.)

Maschinenfabrik Augsburg-Nürnberg A.G., Augsburg. (AUGSBURG.)

Phoenix-Rheinrohr A.G., Mulheim, Ruhr. (DUSSELDORF.)

Stahl-und Röhrenwerke Reisholz A.G., Dusseldorf-Reisholz. (DUSSELDORF.)

Ruhrstahl A.G., Henrichshutte Hattingen-Ruhr. (DORTMUND.)

L. & C. Steinmuller G.m.b.H., Gummersbach/Rhld. (HAMBURG.)

Holland

"Breda," N.V. Machinefabrik, v/h Backer & Rueb, Rotterdam. (ROTTERDAM.)

Bronswerk-Amaf., Amersfoort. (AMSTERDAM.)

N.V. Hk. Jonker & Zoon, Amsterdam. (AMSTERDAM.)

Nederlandsche Electrolasch Mij. N.V., Leiden. (ROTTERDAM.)

Rotterdamsche Droogdok Maatschappij, N.V., Rotterdam. (ROTTERDAM.)

Stork, Gebr., & Co. N.V., Hengelo. (AMSTERDAM.)

Werkspoor, N.V., Amsterdam. (AMSTERDAM.)

Italy

Acciaieria & Tubificio di Brescia, Brescia. (GENOA.)

Ansaldo Stabilimento Meccanico, Genoa. (GENOA.)

Cantieri Riuniti dell'Adriatico. (TRIESTE.)

Franco Tosi S.p.A., Legnano. (GENOA.)

Japan

Harima Shipbuilding & Engineering Co., Ld., Aioi. (KOBE.)

Hitachi Shipbuilding & Eng. Co. Ld., Innoshima Shipyard, Innoshima. (KOBE.)

Ishikawajima Heavy Industries, Tokyo. (YOKOHAMA.)

Ishikawajima Shibaura Turbine Co. Ltd., Tsurumi Works, Yokohama. (YOKOHAMA.)

Japan—*continued.*

Kawasaki Dockyard Co., Ld., Kobe. (KOBE.)

Kobe Shipyard & Engine Works, Mitsubishi Heavy Ind., Reorganised, Ld., Kobe. (KOBE.)

Maizuru Dockyard, Iino Sangyo Kaisha, Ld., Amarube, Maizuru. (KOBE).

Mitsubishi Shipbuilding & Engineering Co., Ld., Hiroshima. (Kobe.)

Mitsui Shipbuilding & Engineering Co., Ld. Tamano. (KOBE.)

Nagasaki Works, Mitsubishi Zosen Kabushiki Kaisha, Nagasaki. (KOBE.)

Nippon Steel Tube Co., Tsurumi. (YOKOHAMA.)

Uraga Shipbuilding Yard, Uraga Dock Co., Ld., Yokosuka. (YOKOHAMA.)

Yokohama Shipyard & Eng. Works Mitsubishi Nippon Heavy Industries, Ld. (YOKOHAMA.)

Norway

Elektrisk Sveisning Bekkegaten (OSLO.)

South Africa

Babcock & Wilcox of Africa (Pty.) Ld., Houtkop Road, Duncanville-Vereeniging. (VEREENIGING.)

Vanderbijl Engineering Corporation, Ld., Vecor Works, Vanderbijl Park, N.W.7, Transvaal. (DURBAN.)

Spain

Empresa Nacional Bazan, El Ferrol. (BILBAO.)

Sweden

Avesta Jernverks A/B, Avesta. (STOCKHOLM.)

Degerfors Jernverks A/B, Degerfors. (GOTHENBURG.)

Eriksbergs Mek. Verkstads A/B, Gothenburg. (GOTHENBURG.)

Landsverk A/B, Landskrona. (HELSINGBORG.)

Lindholmens Varv., A/B, Gothenburg. (GOTHENBURG.)

Marinverkstäderna, Örlogsvarvet, Karlskrona. (MALMO.

Motala Verkstad A/B, Motala. (GOTHENBURG.)

Svetsmekano, A/B, Gothenburg. (GOTHENBURG.)

Switzerland

Brown-Boveri, Ld., Baden. (WINTERTHUR.)

Sulzer Bros., Winterthur. (WINTERTHUR.)

U.S.A.

Babcock & Wilcox Co., Barberton, Ohio. (CLEVELAND, OHIO.)

Bethlehem Steel Co., Bethlehem, Pa. (PHILADELPHIA.)

U.S.A.—*continued.*

Bethlehem Steel Co., Shipbuilding Division, Quincy Works, Mass. (BOSTON.)

Chicago Bridge & Iron Co., Birmingham, Alabama. (MOBILE.)

Combustion Engineering Co., Inc., New York.
Works at Chattanooga, Tennessee. (MOBILE.)
Works at St. Louis. (PHILADELPHIA.)

Downington Iron Works, Inc., Downington, Pa. (PHILADELPHIA.)

Farrar & Trefts, Inc., Buffalo, N.Y. (CLEVELAND, OHIO.)

Foster Wheeler Corporation, Carteret, N.J. (NEW YORK.)

Foster Wheeler Corporation, Mountaintop, Pa. (PHILADELPHIA.)

Griscom-Russell Co., Massillon, Ohio. (CLEVELAND.)

Heilman Boiler Works, Allentown, Pa. (PHILADELPHIA.)

Johnston Brothers, Inc., Ferrysburg, Michigan. (CLEVELAND, OHIO.)

Kellogg, M. W., Co., Jersey City 3, N.J. (NEW YORK.)

Smith, A. O., Corporation, Milwaukee, Wisconsin. (NEW YORK.)

Sun Shipbuilding & Dry Dock Co., Chester, Pa. (PHILADELPHIA.)

FORGE WELDING

John Thompson (Wolverhampton) Ld., Wolverhampton. (BIRMINGHAM.)

September, 1955.

Chapter K

SPARE GEAR FOR STEAM AND INTERNAL COMBUSTION MACHINERY INSTALLATIONS

FOR THE EFFICIENT OPERATION OF THE SHIP THE FOLLOWING ARTICLES OF SPARE GEAR, SO FAR AS THEY ARE APPLICABLE, SHOULD BE SUPPLIED. OWNERS SHOULD ARRANGE TO REPLACE OR MAKE GOOD USED ITEMS AS OPPORTUNITY OCCURS.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	MAIN PROPELLING MACHINERY			
	STEAM RECIPROCATING ENGINES (*See also* items 20 and 21)			
1	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts for one connecting rod.
2	Piston Rings	1 set	1 set	Rings and springs for H.P. Piston.
3	Piston Valve Rings	1 set	—	Rings and springs, of each size used.
4	Piston Rod Metallic Packing	1	—	Complete set of packing for H.P. piston rod and valve spindle.
5	Poppet Valves	1	—	Valve complete with cage, spindle and bush, of each size used, together with rollers and springs.
	STEAM TURBINES (*See also* items 20 and 21)			
6	Bearing Bushes	1	—	Complete bearing bush, of each size and type used, for the rotor, pinion and gear wheel shafts, for one engine.
7	Turbine Thrust	1 set	1 set	Pads of each size for one face of Michell type thrust, or rings for turbine adjusting block, of each size used for one engine. Assorted liners for 1 block where fitted.
	HEAVY OIL ENGINES (*See also* items 20 and 21)			
8	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves, of each size and type used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
9	Piston (including piston exhaust valves where used)	1	—	*Crosshead Type.* Piston, of each size used, complete with rings, studs and nuts.
		1	—	*Trunk Piston Type.* Piston of each size used, complete with skirt, rings, studs, nuts and gudgeon pin.
10	Piston Rings (including rings for piston exhaust valves where used)	1 set	1 set	Rings, of each size used, for one cylinder.
11	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
12	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	—	Top end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
13	Scavenge Blower NOTE : Where there are two scavenge blowers connected to all cylinders, spare gear may be omitted provided the engines can manœuvre satisfactorily when one of the blowers is not in action.	1 set	—	Rotors, rotor shafts, bearings and synchronising gear wheels or equivalent working parts if of other types.
14	Valves for Scavenge System	¼ set	¼ set	Suction and delivery valves, for one engine.
15	Cam-shaft, Scavenge Blower and other Drives	1 set	—	*Gear Wheel Drive.* Wheels for the drive of one engine.
		6	—	*Chain Drive.* Separate links with pins and rollers of each size used.
16	Fuel Pumps	1	1	Pump complete.
17	Reduction and/or Reverse Gear Case Bearing Bushes	1	—	Complete bearing bush, of each size fitted in the gear case assembly.
		1	—	Roller or Ball race, of each size fitted in the gear case assembly.
18	Main Engine Driven Air Compressor	1 set	1 set	Piston rings of each size used.
		½ set	½ set	Suction and delivery valves complete, of each size used.
19	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	APPLICABLE TO ALL TYPES OF MAIN ENGINES			
20	Main Thrust Blocks	1 set	1 set	Pads for one face of Michell type thrust block
				or
		1	1	Complete white metal thrust shoe of solid ring type
				or
		1	1	Inner and outer race with rollers where roller thrust bearings are used.
21	Coupling Bolts	1 set	—	Bolts, of each size used, for one coupling.
	PETROL AND PARAFFIN ENGINES	The items of spare gear to be carried for petrol and paraffin engines employed for main propulsion are to be equivalent to those required for main heavy oil engines.		
	ELECTRIC PROPELLING MACHINERY	For items of spare gear to be carried *see* L 12.		

AUXILIARY MACHINERY

Where additional units of adequate capacity are fitted no spare gear is required.

	AUXILIARY HEAVY OIL ENGINES	For each size of engine required for essential services.		
22	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve, complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves of each size used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.
23	Piston Rings	1 set	1 set	Rings of each size used, for one cylinder.
24	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
25	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
26	Valves for Scavenge System	¼ set	¼ set	Suction and delivery valves, for one engine.
27	Fuel Pumps	1	1	Pump complete.
28	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.
	PETROL AND PARAFFIN ENGINES	The items of spare gear to be carried for petrol and paraffin engines employed for essential auxiliary services are to be equivalent to those required for auxiliary heavy oil engines.		

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	AUXILIARY STEAM ENGINES	For each size of engine required for essential services.		
29	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts.
30	Piston Rings	1 set	1 set	Rings.
	TURBINES DRIVING ESSENTIAL AUXILIARIES	Spare gear to be the same as for main steam turbines in so far as applicable.		
	AUXILIARY AIR COMPRESSOR			
31	Piston Rings	1 set	1 set	Rings, of each size used, for one piston.
32	Valves	½ set	½ set	Suction and delivery valves, complete, of each size used.
	ELECTRICAL EQUIPMENT	For items of spare gear to be carried *see* M 24.		
	REFRIGERATING INSTALLATIONS IN SHIPS	For items of spare gear to be carried *see* N 6.		
	BOILERS			
	MAIN BOILERS			
33	Tube Stoppers or Plugs	20	10	Tube stoppers or plugs, of each size used, for boiler, superheater and economiser tubes.
34	Fire Bars	1 set	½ set	Fire bars for one boiler, where coal fired.
35	Oil Fuel Burners	1 set	1 set	Oil fuel burners complete, for one boiler.
36	Gauge Glasses	2 sets per boiler	2 sets per boiler	Gauge glasses of round type.
		1 set for every two boilers	1 set for every two boilers	Gauge glasses of flat type.
	DONKEY BOILERS	NOTE: If a donkey boiler is the only boiler supplying sufficient steam for essential auxiliary services, the spare gear is to comply with items 33 to 36, where applicable.		
37	Tube Stoppers or Plugs	6	6	Tube stoppers or plugs, complete.
38	Oil Fuel Burners	1 set	1 set	Oil fuel burners, complete, for one boiler.

Chapter L

ELECTRIC PROPELLING MACHINERY

(For Tables and Appendixes see Chapter M)

Section 1

GENERAL

101 In ships propelled by electrical machinery, either wholly or partly by this means, the Rules with regard to machinery are the same as those relating to steam engines so far as regards the testing of material used in their construction and fitting of sea connections, suction and discharge pipes, shafting, stern tubes and propellers.

102 The following Rules are also to be observed. These relate to the electric propulsion equipment, with such references to the mechanical equipment as are required for the successful operation of the combined system. Such requirements are additional to those detailed in the appropriate Chapters of the Rules.

Section 2

CONSTRUCTION

201 In ships built under special survey and fitted with electric propelling machinery, the whole of the electrical machinery, including switch gear, control gear, cables, main and auxiliary generators, motors and exciters, is to be constructed under special survey.

Any alterations and additions to the installation which are made are to be carried out under the inspection and to the satisfaction of the Surveyors.

202 In the cases of electric propelling machinery or engines being built under special survey, the distinguishing mark ✠ will be noted in the Register Book thus :—✠LMC.

203 In order to facilitate the inspection, the plans of the machinery, control gear, cables and electric circuits are to be submitted for approval.

204 The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions has been satisfactorily carried out. Any defects are to be pointed out as early as possible.

205 Any novelty in the construction, operation or application of the machinery is to be reported to the Committee and submitted for approval.

Section 3

STEAM ENGINES FOR PROPULSION GENERATORS

Governing

301 An efficient governor is to be incorporated which is to be arranged so that when operating at rated speed and the rated load is thrown off, the maximum variation in speed is not to be sufficient to bring the emergency governor into operation.

Speed Control

302 When the propeller speed is arranged to be varied by controlling the engine speed the control is to be arranged to permit increments and decrements of speed not exceeding one per cent of maximum speed between 50 per cent and 100 per cent of maximum rated speed.

Maximum Speed

303 The engines are to be capable of withstanding for five minutes without injury a speed of 15 per cent in excess of the maximum rated speed.

Emergency Governor

304 An emergency overspeed governor, independent of the main governor, is to be arranged to trip the throttle valve when the speed exceeds the rated maximum running speed by not less than 10 nor more than 15 per cent. It is also to be arranged for hand tripping.

Mixed Pressure Turbines

305 If, in the case of a turbine, exhaust steam can be admitted to the lower stages, an automatic shut-off controlled by the governor and emergency trip is also to be provided.

Bled Steam

306 When provision is made for bleeding steam from the intermediate stages of a turbine, non-return valves, or positive shut off-valves operated by the emergency governor, are to be fitted.

Torque Limiting

307 In cases where the arrangements permit a propelling motor to be connected to generating plant having a continuous capacity higher than the motor rating, means are to be provided to limit the continuous input to the motor to approximately five per cent above the torque for which the shaft is approved.

Mechanical Balance

308 The engines and generators are to be so constructed, erected and supported that when running at any and every working speed all revolving and reciprocating parts are well balanced so as not to give rise to any appreciable vibration.

Cross-reference

309 For lubricating oil supply to steam turbine driven sets, *see* Chapter E.

Section 4

OIL ENGINES FOR PROPULSION GENERATORS

Governing

401 An efficient governor capable of rapidly shutting off the flow of oil fuel is to be provided.

Critical Speed

402 When coupled to the generator or generators, the combined set must not run in the vicinity of a serious critical at any designed running speed, or range of speeds.

403 Calculations of the torsional vibration characteristics for the dynamic system formed by the engine and generator or generators are to be submitted for consideration together with plans of all shafting.

These calculations should include the particulars required by H 701.

404 In certain cases the Committee may consider it necessary for torsiograph readings to be taken from the machinery after fitting on board, for the purpose of verifying that serious critical speeds do not occur within the range of working speeds.

Rating

405 The engine is to be capable, for periods of one hour, of developing a load 10 per cent above its rated output without undue heating of the engine or other mechanical trouble. The rated output in b.h.p. (unless otherwise approved) is to be the load required to drive the generators and all direct coupled auxiliaries at their continuous maximum rating for a period of 12 hours when working with a barometric pressure of 30 inches of mercury and a surrounding air temperature of 62° F. (16·7° C.).

Section 5

GENERAL REQUIREMENTS OF ELECTRIC PROPULSION MACHINES

Insulation

501 All windings are to be insulated and treated to resist moisture, sea air and oil vapour.

502 All windings are to be insulated from the frame with mica or micanite. Where it is desired to use other types of insulation, particulars regarding the behaviour, properties and life of the materials are to be submitted for consideration.

Terminals

503 The terminals are to be so secured and spaced or shielded that they cannot be accidentally earthed, short circuited or touched. Cable conductors are to be furnished with appropriate sweating sockets.

Coolers

504 If water coolers are employed they are to be arranged so as to prevent leakage or condensation from cooler tubes from entering the machines.

Thermometers

505 Machines having an enclosed ventilating system or ducts for the exhaust air are to be fitted with thermometers for recording the temperature of the ventilating air as it leaves the machine.

Ventilation

506 Ample provision is to be made for supplying cool air to and removing hot air from the machine and to avoid as far as practicable any intake of moist or oil-laden atmosphere.

Where the machines are not ventilated by a closed system, using water coolers, they are to be ventilated with cooling air not exceeding 113° F. (45° C.). In cases where the ventilating air exceeds 113° F. the permissible temperature rise of the machine is to be reduced by an amount equal to the excess temperature.

Heating when Idle

507 All generators of 500 kW or motors of 500 s.h.p. and over are to be provided with efficient means for heating the windings, either electrically or otherwise, to prevent condensation when idle. If steam pipes are used for this purpose, the joints are not to be within the machine.

Shaft Currents

508 Means are to be taken to prevent the formation of circulating currents which might flow between the shafts and the bearings.

Excitation

509 Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent of excitation voltage at the busbars.

510 For large equipments an alternative means of excitation is to be provided. The auxiliary generators may constitute this reserve.

Facilities for Inspection and Repair

511 For the purposes of inspection and repair, provision is to be made for the withdrawal and replacement of the field coils of direct current machines and salient pole alternating current machines, and for sufficient access to stator and armature coils. Facilities are to be provided for supporting the motor shaft to permit the withdrawal and inspection of bearing bushes. Wear-down gauges are to be supplied for generators of 1,000 kW, and motors of 1,000 s.h.p. and over.

Mechanical Protection

512 Suitable handrails or screens are to be provided to prevent personal injury or the entrance of extraneous bodies. All live parts in excess of 250 volts direct-current to earth, or 150 volts alternating-current to earth, are to be suitably guarded or enclosed. Machines are to be amply protected against drip and mechanical damage.

Lubrication

513 Means of lubrication are to be efficient at all running speeds and all normal working oil temperatures, and with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical without the spilling of oil.

514 Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof.

515 Every self-lubricated sleeve bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil. Every self-lubricated bearing is to be fitted with an inspection lid and means for visual indication of the oil level. Where forced lubrication is employed, an alternative means of lubrication, such as oil rings or an oil reservoir, is to be provided if no warning device is fitted, or a period of 30 seconds elapses before the machine comes to rest after the interruption of the oil supply.

The lubrication of propulsion motor bearings is to be effective at trailing speeds under all conditions of oil temperature.

Position in Ship

516 The machines are to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in such a position as to be clear of all inflammable material. Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from or within 4 feet measured vertically above the machines.

517 The machines are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam or oil, and in all ships engaged on open-sea service they are preferably to be placed with their axes of rotation in a fore and aft direction. If placed athwartships end play is to be reduced to a minimum and provision made for the end thrust due to rolling of the ship.

518 Ventilation ducts are to be so arranged that water or extraneous bodies cannot drop into the machines.

Foundations and Bilges

519 Plans of the seatings for the main propulsion generators and motors are to be submitted for approval.

For prevention of accumulation of bilge water, *see* Chapter E.

Manœuvring

520 The torque available for manœuvring is to be reasonably in excess of the trailing action of the propeller to enable the latter to be stopped or reversed in a reasonable time when the ship is travelling at maximum service speed.

Plant to be Earthed

521 The bedplates and frames of the machines are to be effectively earthed, and insulation is not to be interposed between the prime movers and the generators.

Section 6

ALTERNATING CURRENT SYSTEMS

Limiting Pressures

601 The pressure under normal working conditions at any part of the system for equipments not exceeding 15,000 s.h.p. per shaft is not to exceed the following values.

Between lines ... 3,500 volts.
To earth ... ... 2,020 volts.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

Stator Laminations

602 Laminations are to be securely clamped, and are to be efficiently and permanently supported around the whole of the periphery.

603 Laminations are to be suitably insulated from one another with an approved durable material.

Propulsion Generators

604 The ratings and limits of permissible temperature rise for alternators are to conform to Chapter M, Appendix 4. If the ventilating air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

Where sea water cooling is used and the temperature of the sea water does not exceed 85° F. (29·5° C.) the temperature rises specified in Appendix 4 may be increased by 18° F. (10° C.) when measured in relation to the inlet temperature of the cooling water.

605 Machines of 5,000 kVA and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

606 Suitable space is to be provided for the removal of the rotor for the inspection of the rotor and stator.

607 Stator and rotor windings are to be suitable for manœuvring in accordance with 615 without impairment.

Propulsion Motors

608 The ratings and limits of permissible temperature rise for motors are to conform to Chapter M, Appendix 4.

Where the temperature of the cooling air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

Where sea water cooling is used and the temperature of the sea water does not exceed 85° F. (29·5° C.) the temperature rises specified in Appendix 4 may be increased by 18° F. (10° C.) when measured in relation to the inlet temperature of the cooling water.

609 The collector rings and rotor terminals of synchronous type motors are to be suitably insulated for the voltage induced during manœuvring. Insulating barriers are to be provided where necessary.

610 Induction rotor windings of synchronous type motors, used for manœuvring purposes, are to be mechanically strong and of ample section to prevent overheating during repeated manœuvres in accordance with 615.

611 Provision is to be made for machining the collector rings or for their easy removal for that purpose.

612 Machines of 5,000 s.h.p. and over, or machines having an axial core length of one metre or over, are to have at least three embedded temperature detectors and a temperature indicating instrument. Detectors of this type should be fitted to smaller machines where practicable.

Stability

613 The motors and generators are to be designed and arranged to maintain electrical stability and to remain in step under all normal conditions of running.

Excitation

614 Exciters, balancers, boosters and motors for driving them are to conform to Chapter M, Appendix 3, except that for all ocean-going ships and ships operating in tropical waters the temperature rise, measured by thermometer at the rated load, is not to exceed the limit shown in the following schedule :—

	Temperature Rise	
	Class A Insulation	Class B Insulation
Windings (other than single-layer field windings with exposed surfaces) and cores with which they are in contact	63° F. (35° C.)	81° F. (45° C.)
Single-layer field windings with exposed surfaces	81° F. (45° C.)	108° F. (60° C.)
Commutators	72° F. (40° C.)	72° F. (40° C.)

Where the ventilating air adjacent to the machine exceeds 113° F. (45° C.) the permissible temperature rise of the machines is to be reduced by an amount equal to the excess temperature.

615 After a full load run of the complete equipment, for not less than three hours, followed by a full speed reversal and five normal manœuvres within a period of 30 minutes, the temperature rise of any machine supplying the extra excitation required for alternating current systems, is not to exceed that permitted in 614 by 18° F. (10° C.).

Ample margin in the temperature rise of machines is to be allowed for inadvertent delay in the operations of manœuvring referred to above.

616 Field windings and all machines supplying over-excitation during manœuvring are to be capable of withstanding the excess current over a reasonable period, to allow for inadvertent delay during a reversal operation, without impairment, after attaining the temperature rise corresponding to normal continuous working.

617 Negative boosters are, when necessary, to be provided with overspeed protection.

618 The strength of shafts and couplings of exciting machines for alternating current equipments is to be suitable for the increased output necessary during manœuvring.

Section 7

DIRECT CURRENT SYSTEMS

Limiting Pressures

701 For equipments not exceeding 15,000 s.h.p. per shaft the pressure to earth at any part of the system under normal working conditions is not to exceed 600 volts. The voltage of any single armature is not to exceed 1,000.

Proposals involving higher voltages for larger equipments are to be submitted for consideration.

Propulsion Generators and Motors

702 The ratings and limits of permissible temperature rise are to conform to Chapter M, Appendix 4.

Where the temperature of the cooling air exceeds 113° F. (45° C.) the permissible temperature rise is to be reduced by an amount equal to the excess temperature.

Where sea water cooling is used and the temperature of the sea water does not exceed 85° F. (29·5° C.) the temperature rises specified in Appendix 4 may be increased by 18° F. (10° C.) when measured in relation to the inlet temperature of the cooling water.

Brush Gear

703 The brushes are to be staggered longitudinally to prevent the formation of ridges on the commutators and arranged in such manner that in multipolar machines every part of the commutator working surface is swept by an equal number of positive and negative brushes.

Brush gear is to be mounted on the frame or bed-plate of pedestal-bearing machines having an output of 150 kW per 1,000 revolutions per minute and above.

Excitation

704 The arrangements for motor and generator excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously opened or the generator voltage is immediately reduced to zero.

Overspeed Protection

705 Overspeed protection devices are to be arranged to interrupt the supply of power, and the armatures are to be suitably constructed to prevent damage due to temporary overspeeding, where the system permits excessive overspeeding at light loads.

Section 8

GENERAL REQUIREMENTS FOR PROPULSION CONTROL GEAR AND SWITCHBOARDS

Position

801 Control boards and switchboards are to be placed in accessible, well-ventilated positions, free from inflammable gases and acid flames, and in which they are not exposed to risk of mechanical injury or damage from water, steam or oil.

802 Unprotected woodwork or other combustible material is not to be fitted within a distance of 12 inches measured horizontally from, or 4 feet measured vertically above, any live metal.

803 Essential controls for manœuvring operations are to be grouped at the starting platform and any necessary instruments and gauges are to be in direct view from this position.

General Construction

804 Switchboards and control panels are to be constructed wholly of durable, non-ignitable, non-absorbent materials.

805 If insulating material be used for the base, it is to be of permanently high dielectric strength and insulation resistance, and full particulars regarding its properties should be submitted for consideration.

Where used for panels such materials are to be coated with insulating varnish or enamel over their entire surface including such parts as have been exposed by drilling or other machining operations.

806 If semi-insulating materials such as marble or slate are used, all conducting parts are to be insulated from the slate or marble slab with mica or other approved non-hygroscopic insulating material, and the slab is to be similarly insulated as a whole from the frame on which it is mounted; the frame is to be effectually earthed.

807 The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating materials, that an arc cannot be maintained between any such parts, or between such parts and earth.

808 All parts, including connections, are to be readily accessible from the front or back. Fuses are to be placed in approved positions.

809 Omnibus bars and ordinary bare connecting conductors on switchboards are to be proportioned so that their average temperature will not rise more than 54° F. (30° C.) above that of the surrounding air when rated at 2,000 amperes or below when the maximum current flows through them continuously. For bare conductors rated above 2,000 amperes the temperature rise is not to exceed 72° F. (40° C.). The temperature rise of each part is not to exceed the average temperature by more than 9° F. (5° C.) and in other respects they are to comply with Chapter M, Appendix 1. Aluminium is not to be used.

810 All cable connections in the control and switchgear in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and have a sectional area of not less than ·0045 square inch (7/·029 in.).

811 All nuts and screws securing electrical connections are to be effectively locked so that they cannot become loose.

812 All circuits, instruments and important apparatus are to be clearly and indelibly labelled for identification. If detachable name plates are employed, they are to be non-ignitable, and if of metal are to be disposed so as not to involve risk of short circuits or earths.

813 Each voltmeter, wattmeter, voltage coil and pilot or earth lamp with its connecting wires is to be protected individually by a fuse on each insulated pole close to the source of supply. Potential transformers for instruments, relays, etc., may be protected by fuses on the primary side only. Pilot lamps and indicating lamps may have common fuses.

814 Switches and contactors are as far as practicable to be connected so that their blades or moving parts are not alive in the off or de-energised position.

815 Where switches and fuses are fitted on the same pole they are to be arranged so that the fuses are not alive when the corresponding switches are in the off position.

816 Switches and circuit breakers are to conform to the requirements of M 345 to M 361.

817 Fusible cut-outs are to comply with the requirements of M 362 to M 369, and are to be suitably labelled with the circuits or devices which they control.

818 All levers, handles, handwheels, interlocks, and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they cannot be broken by manual operation.

819 Suitable interlocks, preferably mechanical, are to be provided to prevent damage by improper operation, such as the opening of switches or contactors not intended to be operated while carrying current.

820 Provision is to be made for the manual operation of all manœuvring contactors, switches, field regulators, or controllers with reasonable effort, without the aid of solenoids or other electric, pneumatic or hydraulic aid. If such aid be used for normal operation, failure of the electric, pneumatic or hydraulic aid must not result in interruption of power to the screw shaft and the device must be capable of purely manual operation without any delay in changing over to manual control.

NOTE.—This requirement does not apply to bridge control.

821 Where voltage coils are used for relays or for retaining purposes, the coils and resistances in series with them, if any, are to be of substantial and reliable construction where failure of such coils would result in the interruption of the supply of power to the propeller shaft. The number of such coils in a propelling system and the number of auxiliary contacts in series with them are to be reduced to a minimum.

822 The cases of all instruments using a higher pressure than 250 volts direct current to earth or 150 volts alternating current to earth, and secondary windings of all instrument transformers, are to be earthed.

823 Switches normally subject to arcing, such as the short circuiting and isolating switches for direct current generators connected in series, are to be provided with substantial and renewable arcing tips.

824 All apparatus is to be arranged to function satisfactorily under conditions of vibration and shock, and with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and when rolling up to 22½ degrees from the vertical.

825 Shunt-operated contactors, releases, and relays are to be capable of functioning satisfactorily even when the line voltage falls to 80 per cent and 85 per cent for direct current circuits and alternating current circuits respectively, with the coils at the temperature which they will attain under normal service at the normal line voltage, and, in the case of alternating current circuits, at rated frequency.

826 For the purpose of maintaining alignment and ease of operation, operating shafts are to be fitted with flexible couplings and expansion joints where necessary and means are to be provided for effective lubrication.

827 All steel parts, including springs, are to be suitably treated to resist corrosion.

Overload and Short Circuit Protection

828 Provision is to be made for protection against severe overloads or electrical faults likely to result in serious injury to the plant, but the operating point is to be set sufficiently above the currents and loads usually experienced in a heavy sea-way or when manœuvring, to prevent interruption of power.

Earth Detection

829 The main propelling circuit is to be provided with means for detecting earth faults.

830 For D.C. equipments exceeding 500 volts and for all A.C. equipments, aural and visual alarms are to be operated, but power supply is not to be interrupted on the occurrence of a fault, so that the plant may continue to operate with a single earth. If an earth connection be used for the operation of the detector, the arrangements are to be such that the earth circuit is automatically opened in order to stop the circulation of fault current.

831 Earth detection devices are to be arranged to function for all earth leakage faults exceeding five amperes. On three-phase alternating current systems at least 95 per cent of the generator and motor windings are to be protected.

832 A switch may be installed to cut out the aural device to prevent continuous alarm, but in such case the visual device is to be automatically switched on when the aural device is switched off.

833 Excitation circuits are to be provided with lamps, voltmeters or other suitable means to indicate continuously the state of the insulation of the system under running conditions.

Mechanical Protection

834 All exposed current-carrying parts having a potential of over 250 volts direct current to earth or 150 volts alternating current to earth are to conform to the following requirements :—

Terminals are to be enclosed.

The sides and rear of switchboards and control panels are to be suitably screened.

Access doors are to have prominent and permanent nameplates giving the maximum voltage, and are to be interlocked to prevent access while such parts are alive, or in approved cases are to be provided with a special key under the care of the chief engineer.

Exposed current-carrying parts exceeding 250 volts to earth are not to be permitted on any switchboard or control panel.

Bridge or Deck Control

835 The control is to be simple and easy to operate.

836 It is to be such that the operator cannot produce currents or loads in excess of the working capacity for which the plant is designed.

837 Control is to be carried out without reference to electrical instruments.

838 Alternative control in the engine room is to be provided, and so arranged that transfer of control to the engine room can be made in emergency without excessive loss of time.

839 It is to be arranged so that simultaneous control of the propelling machinery from the bridge and engine room is not possible.

Instruments and Gauges

840 Instruments and gauges which are necessary for the efficient operation of the plant are to be provided. Particulars are to be submitted for consideration. In cases where the rotation of the propeller motors cannot readily be observed from the starting platform, indicators are to be provided.

841 All essential instruments are to be capable of withstanding vibration and shock without impairment and are to be fitted in moisture-proof cases.

842 Instruments are where necessary to be protected from the influence of stray magnetic fields.

843 A 500 volt insulation tester, giving the resistance in megohms, for the purpose of testing and tracing faults is to be carried on all sea-going ships.

Discharge Protection

844 For the protection of the field windings and cables efficient means are to be provided for limiting the induced voltage when the field circuits are opened.

845 Where excitation is obtained from the auxiliary busbars efficient means are to be provided to limit the induced voltage on the busbars when the generator or distribution circuit breaker opens.

Direct Current Systems

846 Where two or more direct-current generators are connected in series, means are to be provided to prevent the reversal of the prime mover on the failure of the power supply to any one generator if such reversal would result in damage or overspeeding.

847 If the regenerated energy transmitted by the propeller motor on stopping or reversing the propeller is of a magnitude that would cause an undue increase in the engine speed, means are to be provided for suitably absorbing or limiting such power.

848 Where the propulsion generators are also to be used for other purposes, suitable overload protection and provision for voltage adjustment are to be arranged in conformity with the requirements of Chapter M.

Reversing Switches

849 Contactors or switches used for reversing the rotation of the propeller are to be mechanically interlocked to prevent the circuits for ahead and astern rotation being closed simultaneously.

850 The reversing contactors or switches are also to be provided with means for forcing them open if they should become stuck in the closed position.

Resistances

851 Resistances are to comply with the requirements of M 1313 to M 1316.

852 Shunt resistances connected across the field circuit of synchronous propelling motors when they are functioning as induction motors are to be suitably insulated for the voltage induced when reversing and amply rated to allow for inadvertent delay during the reversing operation.

Temperature Alarm

853 Machines having an enclosed ventilating system or ducts for the exhaust air are to have an aural alarm device arranged to operate when the outgoing air exceeds the predetermined safe value.

Reversing Levers and Handwheels

854 Propeller reversing levers or handwheels are to be clearly and permanently marked with the positions for ahead and astern working. Levers or handwheels placed athwartships are to be arranged for right hand or clockwise rotation for ahead working or if operated in a fore and aft direction to be arranged to correspond with the direction in which the ship is moving.

Auxiliary Power

855 Distribution circuits connected to the auxiliary busbars for excitation and lubricating oil pumps, etc., are to be suitably protected from interruption due to overloading of non-essential circuits.

Speed Control

856 In multiple-propeller ships where the propeller speed is arranged to be varied by voltage control or other electrical method, means are to be provided to permit an adjustment between 50 per cent and 100 per cent of maximum rated speeds in a suitable number of steps.

Section 9

CONDUCTORS AND CABLES

Conductors

901 All conductors are to be of annealed copper conforming to the Standards of the International Electrotechnical Commission Publication No. 28.

902 Where the insulating covering of the conductor contains sulphur, each wire is to be efficiently and uniformly coated with tin free from all impurities.

903 Conductors in any circuit essential for manœuvring or maintenance of propelling power are to be stranded and to consist of not less than seven strands and to have a sectional area not less than ·0045 square inch (7/·029 in.).

904 The size of conductor is to be selected so that the drop in voltage, when carrying rated full load and overloads, is not greater than that allowed for in the design of the machines.

905 The current in any conductor is not to exceed that given in Chapter M, Tables I to V, when carrying current continuously or Table VI when intermittently loaded. In no case is a shorter rating than one half-hour to be taken. In the case of field discharge circuits, particulars should be submitted for consideration.

Field currents, when the windings are cold, are to be taken into consideration when determining the size of conductors.

906 Where multicore cables are used the dimensions are to be submitted for approval.

907 Busbars and connections are to be in accordance with Chapter M, Appendix 1, and, if used for connections to machines, must be rigidly and strongly supported, efficiently

insulated and guarded, and protected from drip and jets of liquid or steam. Pipes are not to enter ducts containing such connections. Suitable means are to be arranged for draining any accumulation of moisture in ducts.

Insulation and Protective Covering of Cables

908 All cables are to conform to the requirements of M 7.

Installing and Fixing of Cables

909 All cables are to be installed and fixed in conformity with the requirements of M 9.

910 Cables are to be run in accessible, well-ventilated positions where they can be easily inspected.

Cables for Alternating Currents

911 Where single-core cables are used for alternating current circuits rated in excess of 5 amperes :—

The armouring, if any, is to be non-magnetic material.

Magnetic material is not to be used between such cables.

Such cables are to be so arranged that the inductive effects of the groups are substantially eliminated.

912 Single-core lead-alloy sheathed cables are to have their lead sheaths bonded together and earthed only at approximately the mid-point of the cable run, or alternatively, earthed at both ends, provided that, in the latter instance, the cross-sectional areas of the cables are so increased as to compensate for the increased heating. In the former case such cables are to be carried on insulators to prevent the circulation of currents in the metal sheaths. The sheaths of multicore cables are to be earthed at each end and long runs are also to be earthed intermediately.

913 Magnetic material is not to be used between single core cables of a group. Where cables pass through bulkheads or steel panels, all the conductors of the same set are to pass through a non-ferrous plate or gland so that no magnetic material passes between the cables, and the clearance between the cables and magnetic material is to be not less than three inches.

NOTE.—This paragraph does not apply to cables carrying 10 amperes or less.

914 Single core cables are to be so arranged that the inductive effects of the group are practically eliminated.

Cable Sockets

915 Large cable sockets are preferably to be secured by two or more studs or bolts, not exceeding $\frac{3}{4}$ inch diameter, and the nuts securely locked.

Synchronous Motor Cables

916 Cables connected to the collector rings of synchronous motors during manœuvring are to be suitable for the voltage induced during those periods.

Interference with Magnetic Compasses

917 Single-conductor circuits carrying continuous current are to be arranged with lead and return conductors fitted as close to one another as possible. Tests are to be made during the adjustment of the compasses to determine the effect of switching the main circuits on and off and careful records are to be kept of any errors observed, whether corrected or not.

Section 10

SECONDARY BATTERIES

General

1001 All batteries are to conform to the requirements of M 16.

Capacity

1002 Batteries used for starting main propulsion engines in lieu of compressed air are to comply with the following :—

If used for purposes other than starting, full particulars of the battery should be submitted for consideration. These particulars should include the capacity which it is estimated will be required to give not less than six consecutive starts of each main engine, also details of the other uses for which the battery is intended; the facilities for charging should also be indicated.

If used solely for starting main engines two batteries are to be fitted each capable of starting each main engine six times in succession without recharging. Details of the charging arrangements are to be submitted for consideration.

Plans showing the location and arrangement of battery compartment are to be submitted for approval.

Section 11

TRIALS

Works Tests

1101 The machines, switchgear, main cables and control gear, are to be tested in the presence of the Surveyors at the makers' works so far as practicable to ensure compliance with the requirements relating to temperature rise, dielectric strength, insulation resistance and operating characteristics.

1102 The dielectric test to be applied to the control gear is to be equal to the test for that part of the machine to which it is to be connected or otherwise is to be 1,000 volts plus twice the rated voltage of the circuit with a minimum of 2,000 volts between poles and between current-carrying parts and earth ; the test voltage is to be maintained for one minute and is to be made with alternating current at any convenient frequency between 25 and 100 cycles per second.

1103 The rotor windings of turbine driven alternators are to be tested for insulation resistance when rotating at maximum rated speed, as well as at standstill.

Ship Trials

1104 After installation on board the entire propelling equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction.

The insulation resistance of the main windings of each machine in megohms should be not less than

$$\frac{3 \times \text{rated voltage}}{\text{rated kVA} + 1000}$$

The insulation resistance of cables, field windings and control gear when isolated and separated for testing purposes should be not less than one megohm.

All insulation tests are to be made where possible when the machines are hot and with a D.C. voltage of about 500 applied for sufficient time for the indicator to become practically steady.

Section 12

SPARE GEAR

1201 For the efficient operation of the ship, articles of spare gear, so far as they are applicable, should be supplied as specified in 1202-1205. Owners should arrange to replace or make good used items as opportunity occurs.

1202 Owing to the varied character of equipments an exact list of spares cannot be specified and a list should be submitted for consideration together with or subsequent to the submission of final plans. The articles mentioned in the following paragraphs should be included as a minimum for all ships engaged in open-sea service.

1203 Generators, Motors and Exciters.—

One set of bearing bushes, with oil rings, if used, of each size and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for D.C. generators, exciter and motors.

One set of insulation or insulated brush studs for two lines of brushes of each size and type.

In cases where there is no stand-by exciter or alternative means of excitation, spare armatures for the excitation machines may be required.

One set of slip rings for one motor if of the A.C. type.

1204 Switch and Control Gear.—

One set of contacts liable to burning or wear.

One set of springs.

10 per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors, relays, or trip coils.

Two fuse handles of each type and size, or 10 per cent, but not less than 12 of each type of cartridge or other non-rewireable cut-out.

1205 General.—

Special dismantling tools, if any, required for overhauling machines or control gear.

100 yards of control cable.

A suitable quantity of insulating tape and fuse wire.

1206 Storing.—

Electrical spares should be protected against excessive heat, and against moisture and rodents, and should be periodically tested.

Chapter M

ELECTRICAL EQUIPMENT

(For purposes other than Electric Propulsion)

Section 1

GENERAL

101 In cases in which electricity is used on board classed ships for purposes other than electric propulsion, the following Rules are to be observed.

102 The equipment and installation are to be inspected and tested by the Surveyors.

103 In order to facilitate inspection, an arrangement plan and circuit diagram of the switchboard, also diagrams of the wiring system showing cable sizes, type of insulation, and normal working current in the circuits are to be submitted in triplicate for approval. The plans are to state the insulating material used for the switchboard panels, the materials used for insulating bushes, if any, and the capacity, type and make of fuses.

104 All conductors, switchgear, and accessories, are to be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current which can normally flow through them.

105 Any novelty in construction, materials or design not specifically dealt with in these Rules is to be reported to the Committee.

106 In special cases the Committee are prepared, at the request of the Owners, to accept installations which, whilst not precisely in accordance with the detailed requirements of the Society's Rules, comply either wholly or in part with a Code of Regulations officially recognised by the Law of the Country in which the ship is owned, provided such Code or appropriate section thereof governing the equipment is considered to be equivalent to the Society's Rules.

In such cases the requirements with regard to inspection and testing and the submission of plans are to be carried out in accordance with the Society's Rules.

107 An addition, temporary or permanent, is not to be made to the authorised load of an existing installation until it has been definitely ascertained that the current-carrying capacity and the condition of the existing accessories, conductors, switchgear, etc., affected are adequate for the increased load.

108 Alterations and additions to an existing installation are to be carried out under the inspection, and to the satisfaction, of the Surveyors, and in accordance with the latest requirements of the Rules. If the alterations are extensive, plans are to be submitted for approval.

Standard Systems

109 The following systems of distribution may be used:—

(*a*) Parallel systems with constant pressure, either—

single wire with hull return; or
two-wire with direct or single-phase alternating current; or
three-wire with direct current; or
three-phase three-wire; or
three-phase four-wire.

(*b*) Series systems with constant current (direct current only).

Limiting Pressures

110 The pressure of supply is not to exceed the following values:—

(*a*) With direct-current constant-pressure systems—

for power, 500 volts.
for lighting and heating, 250 volts.

(*b*) With alternating current systems—

for power, single-phase, 250 volts.
for power, three-phase, 440 volts.
for heating, 250 volts.

for three-phase galley heating and cooking equipment permanently connected to fixed wiring, 440 volts.

for calorifiers of 7·5 kW and over and for lubricating and fuel oil heaters, permanently connected to fixed wiring, three-phase, 440 volts.

for lighting and socket outlets, 150 volts to earth.

(*c*) With constant-current series systems (direct current only)—650 volts.

For ships carrying oil having a flash point less than 150° F. (65·5° C.), see M 15.

Section 2

GENERATING PLANT

Prime Movers

201 Where a turbine-driven direct-current generator is arranged to run in parallel with other generators, a switch is to be fitted on each turbine emergency governor to open the generator circuit-breaker when the emergency governor functions. The contacts of the overspeed switch are to be normally closed.

202 The normal running speed of a combined generating set is not to be in the vicinity of a torsional critical speed.

Rating of Generators, etc.

203 Generators, exciters, balancers, and boosters are to conform to Appendix 3.

204 The temperature rise of generators, exciters, balancers and boosters, except pipe-ventilated or water-cooled machines, in all ocean-going ships and ships operating in tropical waters measured in accordance with Appendix 3 and under working conditions is not to exceed the limits shown in Table XXIV.

For pipe-ventilated machines taking cooling air from outside the machinery space where the normal temperature of the cooling air under service conditions will not exceed 104° F. (40° C.) the temperature rise is not to exceed the limits shown in Table XXV.

For water-cooled machines with coolers using water with an inlet temperature not exceeding 85° F. (29·5° C.), temperature rises are to be measured relative to the inlet temperature of the water and the permissible temperature rises shown in Table XXV may be increased by 18° F. (10° C.).

205 The teomperature rise of generators, etc., in ships such as coasters, ferries and harbour craft intended solely for use in northern and southern waters outside the tropical belt is not to exceed the limits shown in Table XXV.

206 Flameproof generators are to conform to Appendix 6.

Excessive Ambient Temperature

207 Where the temperature of the cooling air exceeds 113° F. (45° C.) in the case of machines where Table XXIV applies and 104° F. (40° C.) where Table XXV applies or where water cooling is used and its temperature exceeds 85° F. (29·5° C.) the permissible temperature rise of the machines is to be reduced by an amount equal to the excess temperature.

Direct-Current Generator Characteristics

208 Generators other than those referred to in 212 are to be cumulatively compound wound, except that where parallel-connected generators are installed so far apart as to render excessive the amount of copper in the equalising conductors, the generators may be shunt wound or compound wound with shunt characteristics. The series field windings are to be connected to the negative terminals of the generators.

209 When tested with their prime movers, or when tested separately and the speed regulation of the prime mover is known, unless otherwise specified, generators are to be flat compounded with the shunt field windings self-excited and without alteration to the initial (normal voltage) adjustment of the shunt-field regulators. Where a generator is tested separately and the speed regulation of the prime mover is not known, the permanent increase in speed when the rated load is thrown off is to be taken as 4 per cent of the full load speed, but the generator is to be arranged so that, if required, it can be flat compounded with a permanent increase in speed of 6 per cent.

210 Adjustment of compounding (if required) is to be effected before the acceptance test at the maker's works. For generators larger than 400 kW per 1,000 revolutions per minute this adjustment is to be made by means of diverters, the generator brushes being in the neutral position. For smaller generators this adjustment may, if desired, be made by movement of the brush position, provided that such movement is not to effect an alteration in the voltage of more than 2 per cent of the rated voltage.

211 Where a generator with shunt characteristics is arranged for parallel running with other generators, and is tested with its prime mover (the shunt field winding being self-excited) and with a field setting of the shunt field regulator (*see* 215), the no-load voltage is not to be exceeded at any load, and the no-load voltage is not to exceed the full-load voltage by more than 15 per cent. The requirements of this clause do not preclude the use of compounding for the purpose of obtaining the correct generator characteristics.

212 Generators used for charging secondary batteries without the use of regulating resistors in series with the batteries are either to be shunt wound, or to be compound wound and provided with switches to cut out the series windings.

213 Generators driven direct from the screw shaft or the main engines are to be provided with suitable means for automatically maintaining a constant voltage at the distribution busbars.

214 Diverters are not to be connected across commutating pole windings.

Field Regulation for Direct-Current Generators

215 Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. The equipment provided is to be capable of adjusting the voltage of the generator to within 0·5 per cent of the rated voltage for machines above 100 kW and 1 per cent of the rated voltage for smaller machines at all loads between no-load and full-load, with the generator coupled to its prime mover, at any permissible temperature within the working range. At the conclusion of the full-load temperature test, with full-load current and normal full-load voltage at the terminals when running at full-load engine speed, the voltage across the shunt field regulator with an ambient of 60° F. (15·6° C.) is not to be less than 14 per cent of the terminal voltage of the machine. The regulator is to be capable of reducing the no-load voltage to 10 per cent below the rated voltage with the generator cold and with the same ambient air temperature.

Alternating-Current Generators

216 Where alternating-current generators are installed means are to be provided for automatically maintaining the steady voltage at the busbars within plus or minus 2½ per cent of the normal voltage.

217 In alternating-current systems, with one generator set as standby, the remaining sets are to have sufficient reserve capacity to permit the starting of the largest motor in the ship without causing any motor in service to stall or any other device to fail owing to excessive voltage drop on the system.

Generator Rating Plate

218 Every generator is to be fitted with a rating plate clearly and indelibly marked with the following information :—

Maker's name and machine number.

Nature of supply — D.C. or A.C., voltage frequency, number of phases, etc.

Amps. power-factor, kVA.

Speed.

Winding type, i.e., compound, shunt, separately excited.

Excitation voltage if separately excited.

Testing

219 Every generator is to be tested at the maker's works, and a certificate giving the results is to be submitted for approval. The tests are to include :—

Temperature test at full load.

Regulation (compounding).

Voltage range with shunt regulator.

Insulation resistance.

High voltage test.

Machines of 100 kW and over intended for supplying essential services are to be inspected by the Surveyors during manufacture and testing.

Construction of Generators

220 All working parts of generators are to be readily accessible, and all accessible live parts the voltage of which exceeds 250 volts direct-current to earth or 150 volts alternating-current to earth are to be suitably guarded or enclosed.

221 Only Class A or Class B insulating materials in accordance with Appendix 2 are to be used in the construction of generators. All generator windings are to be insulated from their frames and/or cores with mica or micanite, and the insulation between bar-wound armature conductors between upper and lower layers or equivalent portions, between which there is periodic full rated voltage, are to be of micanite or other non-hygroscopic

non-inflammable material. All generator windings are to be treated to resist moisture, sea air, and oil vapour.

222 Where welding is to be applied to shafts for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

Brush Position

223 The final running position of the brushgear is to be clearly and permanently marked.

Commutator Brushes

224 Generator brushes for use on commutators or sliprings are to be of carbon, graphite, or metal-graphite, and are to be provided with flexible copper connections.

225 Commutator brushes are to be staggered longitudinally in such a manner that in multipolar generators every part of the commutator working surface is swept by the brushes, to prevent the formation of ridges. The staggering is to be so arranged that in multipolar generators a positive brush is always in line with a negative brush on an adjacent brush arm.

Commutator brushgear is to be mounted on the frame or bedplate of pedestal-bearing machines of 150 kW per 1,000 revolutions per minute and above.

Terminals

226 Suitable terminals, clearly marked, are to be provided in an accessible position, convenient for wiring, and except where substantial mechanical cable clamps are supplied they are to be provided with cable sweating sockets. The terminals are to be effectually secured and are to be so spared and/or shielded that they cannot be accidentally earthed, short-circuited, or touched.

Mechanical Balance

227 All generating plant is to be so constructed, erected, and supported, that when running at any and every working speed all revolving and reciprocating parts are well balanced, and the plant is not to give rise to any appreciable vibration on the test bed and in service.

Lubrication

228 Generators and their prime movers are to be efficiently and continuously lubricated automatically at all running speeds and all normal working oil temperatures and, except for the generators of emergency sets (*see* 238), with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and when rolling up to 22½ degrees from the vertical without the spilling of oil. Where ring lubrication is employed, the rings are to be so constrained that they cannot leave the shaft. Oil flingers or other suitable means are to be provided to prevent the lubricant from creeping along the shaft, or otherwise gaining access to the insulation of the machine or any live part thereof. Every oil-lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil.

229 Every self-lubricated sleeve bearing is to be fitted with an inspection lid and means for visual indication of the oil level.

Plant to be Earthed

230 The bedplates and frames of the generating plant are to be effectually earthed, and insulation is not to be interposed between the prime movers and the generators.

Shaft Currents

231 Means are to be taken to prevent the induction of currents likely to circulate between the shafts and the bearings.

Spare Plant

232 Every sea-going ship in which electric power is used for essential services, is, except where other means are available for maintaining these services, to be provided with two or more generating sets of such combined output that in the event of one set being disabled the remaining generating plant is capable of supplying the essential services.

Position in Ship

233 The compartments in which the machines are placed are to be well ventilated, and free from the likelihood of an accumulation of inflammable gases. The machines are to be clear of all inflammable material and easily accessible, and they are to be so arranged that under any condition of excitation the compasses are not appreciably affected.

234 Generators are to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil. Every open-type generator is to be fitted with a canopy to protect the windings and commutator or sliprings from drip. Suitable handrails are to be provided where necessary to obviate the risk of injury to persons.

235 Generators other than those of emergency sets are preferably to be placed with their axes of rotation in a fore-and-aft direction.

236 No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any generator, unless the latter is of the enclosed type.

Ventilation

237 Ample provision is to be made for supplying clean cool air to, and removing hot air from, the generators, and for preventing the admission of moist or oil-laden atmosphere. Where the generators are not ventilated by a closed system using water coolers, they are to be ventilated with cool air.

Emergency Sets

238 Emergency sets are, if practicable, to be placed with their axes of rotation in a fore-and-aft direction. The lubrication and water cooling of emergency sets shall be efficient, without the spilling of oil or water, at all running speeds and all normal working oil temperatures, and with the ship inclined from the normal at any angle up to 22½ degrees transversely and 10 degrees longitudinally.

Clearance from Oil Vents

239 Open-type generators are to be so located that there is adequate clearance from oil vents of gear cases, crank cases, etc., in order to avoid the possibility of the fumes from such vents being drawn into the generators.

240 If water-cooled heat exchangers are used they are to be so arranged as to prevent leakage or condensation from the cooler tubes from entering the machine.

Section 3

SWITCHBOARDS AND SWITCHGEAR

(other than Machine Control Gear, dealt with in M 13)

Position of Switchboards

301 Switchboards are to be placed in accessible well-ventilated positions, free from inflammable gases and acid fumes, and in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil.

Sufficient ventilation and circulation of air are to be provided to dissipate the heat losses and to prevent condensation.

302 No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any live metal.

303 Cupboards or compartments containing switchboards must be composed of fire-resisting material or fitted with approved lining.

Materials

304 Switchboards are to be constructed wholly of durable, flame-retardent, non-absorbent materials of adequate strength except as allowed by 306.

305 Where synthetic insulating material is used, it is to be of permanently high dielectric strength and insulation resistance and non-hygroscopic, and unless it is of the synthetic-resin-bonded sheet type full particulars of appropriate type tests are to be submitted for consideration (*see* Appendix 2, paragraph 2). Only approved materials are to be used. Where used for panels, such materials are to be coated with insulating varnish or enamel over their entire surface, including such parts as have been exposed by drilling or other machining operations.

306 Where semi-insulating materials such as marble or slate are used, all conducting parts on each insulated pole are to be insulated from the slate or marble slabs with bushes and washers of mica or other non-absorbent insulating material.

General Construction

307 The various live parts are to be so arranged, by suitable spacing or shielding with non-ignitable insulating material, that an arc cannot be maintained between any such parts or between such parts and earth.

308 All parts, including connections, are to be readily accessible, and live parts mounted on the back of panels and distribution fuse-boards are to be so screened as to prevent them from being inadvertently touched.

309 Where a voltage exceeding 250 volts direct-current or 150 volts alternating-current to earth is used, the following requirements are to be complied with :—

The sides and rear of switchboards and control panels are to be suitably guarded.

Access doors are to have prominent and permanent nameplates indicating the maximum voltage.

Exposed live parts operating at such voltages are not to be installed on the face of any switchboard or control panel.

310 Every fuse (other than one protecting an instrument or a pilot lamp) fixed on a switchboard is to be fitted on the front thereof, subject to the exception that it may, if desired, be mounted on a framework behind the switchboard, provided that the fuse is well clear of busbars, connections, circuit-breakers, and live parts, and an unobstructed gangway of not less than 2 feet is left behind the switchboard.

311 All nuts and screws which are used in connection with current-carrying parts and working parts are to be effectually locked so that they cannot become loose.

312 The connecting wires to every voltmeter, wattmeter voltage coil, synchroscope and pilot lamp (if any), and to every earth lamp, are to be protected individually by a fuse on each insulated pole, the fuse being placed as near as practicable to the source of supply except that where such instruments are supplied from a potential transformer with fuses on the primary and secondary sides, a single fuse on each live pole of the secondary side of the transformer may be substituted for the individual fuses for each instrument.

313 Switches, circuit breakers and contactors are, whenever practicable, to be so connected that their blades or moving parts are not alive in the off or de-energised position.

314 Every equaliser switch and its busbar is to have a current-carrying capacity of not less than half the full-load current of the generator.

315 Switches and fuses fitted on the same pole are, preferably, to be so arranged that the fuses are not alive when the corresponding switches are in the off position.

316 Where single-pole switches or fuse-switches are required under these Rules, they are to be fitted on the same pole throughout the installation.

317 Where access is provided behind a switchboard, the unobstructed gangway is to be not less than 2 feet in width, except that this may be reduced to 18 inches in way of stiffeners and frames, and an insulated handrail is to be installed behind the panel.

318 Every open-type switchboard is to be provided with an insulated handrail fitted in front of the panel.

Earthing

319 The following parts of switchboards and switchgear are to be effectively earthed :—

The frames, if of metal.

The metal cases of instruments used in circuits having a voltage to earth exceeding 250 volts direct-current or 150 volts alternating-current.

The secondary windings of all instrument transformers.

Busbars, etc.

320 All busbars and busbar connections on switchboards are to be of copper and are to comply with the requirements of Appendix 1.

Fuse-Switches and Circuit-Breakers

321 Where a separate fuse and switch, or separate fuses and a linked switch, are required under these Rules, they may, if desired, be replaced by an overload circuit-breaker (or fuse-switch) or by a linked overload circuit-breaker (or a linked fuse-switch) respectively.

Labels

322 All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labelled for identification. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit-breaker, and marked with particulars of the full-load current of the generator or cable which the fuse or circuit-breaker protects. The labels for rewirable fuses are also to be marked with the appropriate size of fuse-element. Where inverse-time-limit

and/or reverse current devices are provided in connection with a circuit-breaker, the appropriate settings of these devices are also to be stated on the label. Nameplates are to be of flame-retardent material, and, if of metal, they are to be so disposed as not to involve risk of short circuits or earth faults.

Inclination, Vibration and Shock

323 All apparatus is to be arranged to function satisfactorily with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and when rolling up to 22½ degrees from the vertical, and under such conditions of vibration and shock as are likely to arise in practice.

Apparatus connected to the emergency system is to be satisfactory with the ship inclined up to 22½ degrees transversely and 10 degrees longitudinally.

Generator Switchgear

324 Every main switchboard and every emergency switchboard is to be fitted as a minimum with the switchgear as specified in 325 to 328.

325 Where only one direct-current generator is installed, or where more than one generator is installed, the generators not being arranged to run in parallel :—

(*a*) If a single-wire or a two-wire earthed system : either a single-pole overload circuit-breaker, or a fuse and a single-pole switch, on the insulated pole.

(*b*) If a two-wire insulation system : either a double-pole overload circuit-breaker, or a fuse on each pole and a double-pole linked switch.

326 Where more than one direct-current generator is installed, the generators being arranged to run in parallel :—

For each generator : a circuit-breaker with overload and reverse-current trips. If the generator be flat compounded in accordance with M 209, a single-pole equaliser switch is to be so interlocked with each circuit-breaker that it must be closed before the circuit-breaker and cannot be opened until the main circuit is opened. The reverse-current protection is to be connected on the positive pole (i.e., the pole opposite to that on which the equaliser connection is made). In a single-wire system or a two-wire earthed system the circuit-breaker is to be of the single-pole type, and in a two-wire insulated system it is to be of the double-pole type.

327 In direct-current three-wire systems :—

(*a*) For generators not arranged to run in parallel : a three-pole linked circuit-breaker with overload protection in each outer pole.

(*b*) For shunt characteristic generators arranged to operate in parallel : a three-pole linked circuit-breaker with overload protection on each outer pole. Reverse-current protection is to be provided in one outer conductor.

(*c*) For compound-wound generators having the series field winding split (*i.e.* having half the winding connected to each pole) and arranged to operate in parallel : a five-pole linked circuit-breaker (two outers, two equalisers and a neutral) with overload protection between the armature and the points to which the equaliser busbars are connected.

Reverse-current protection is to be provided and connected in one of the armature circuits.

(*d*) In each case, whether for parallel or non-parallel operation, an over-current relay is to be provided in the neutral, arranged to operate an alarm when the current in the neutral connection exceeds 25 per cent of the generator current rating or at a value not exceeding the rating of the generator neutral, whichever is the less.

No overload release is to be fitted in the neutral.

328 Where one or more three-phase alternating-current generators are installed :—

For each generator : a triple-pole linked circuit-breaker with overcurrent trips in at least two phases where the system is three-phase three-wire having the neutral insulated from earth or with overcurrent trips in each phase where the neutral is earthed or where a three-phase four-wire system is used. In a three-phase four-wire system a generator neutral isolating switch or link is to be installed.

Where alternating-current generators are intended for parallel operation, reverse-power relays are to be provided if the generators have a rating exceeding 125 kVA.

Main Switchgear for Outgoing Circuits

329 Every main switchboard and every emergency switchboard is to be provided as a minimum with the switchgear as specified in 330 to 332.

330 Two-wire Direct-Current and Single-phase Alternating-Current Systems

(*a*) If a single-wire or a two-wire earthed system: for each outgoing circuit a fuse and a single-pole switch on the insulated pole.

(*b*) If a two-wire insulated system: for each outgoing circuit a fuse on each pole and a double-pole linked switch.

(*c*) Where two or more generators, not operating in parallel, are installed: multiple-way switches so arranged that each outgoing circuit may at all times be connected to any generator or isolated.

331 Three-wire Direct-Current Systems

(*a*) For each outgoing three-wire circuit where the supply is given to three conductors: either a double-pole linked circuit-breaker controlling the outer conductors, or a fuse on each outer conductor and a double-pole linked switch controlling the outer conductors.

(*b*) For each outgoing two-wire insulated circuit from the middle wire and one outer of a three-wire system: either a double-pole linked circuit-breaker, or a fuse on each pole and a double-pole linked switch.

(*c*) For each outgoing single-wire or two-wire earthed circuit from the middle wire and an outer of a three-wire system: a fuse and a single-pole switch on the insulated pole.

332 Three-phase Alternating-Current Systems

(*a*) For each outgoing three-wire circuit: either a triple-pole linked circuit-breaker with overcurrent trips in accordance with the requirements of 328, or a fuse in each phase and a triple-pole linked switch.

(*b*) For each outgoing two-wire insulated circuit to which a supply is given from one of the three conductors and the neutral: either a double-pole linked circuit-breaker, or a fuse on each pole and a double-pole linked switch.

(*c*) For each outgoing single-wire or two-wire earthed circuit, to which a supply is given from one of the three conductors and the neutral: a fuse and a single-pole switch on the insulated pole.

(*d*) For each outgoing four-wire circuit used to supply a section board or distribution fuse-board from which three-wire or two-wire circuits are supplied: either a triple-pole linked circuit-breaker with an overload trip in each phase, or a fuse in each phase and a triple-pole linked switch.

Prohibition of Fuses and Non-linked Switches in Certain Conductors

333 A fuse, non-linked switch, or non-linked circuit breaker, is not to be inserted in:—

(*a*) The middle wire of a direct current or single-phase three-wire circuit.

(*b*) The neutral of a three-phase four-wire circuit.

(*c*) The earthed conductor of a single-wire or two-wire earthed system.

334 Isolating Link (three-wire and three-phase circuits).—The requirements of 331(*a*), 332 (*b*), 332 (*c*) and 333, do not preclude the provision (for testing purposes) of an isolating link having at least as large a current-carrying capacity as the conductor which it is intended to isolate. Such link is to be securely fixed to its terminals by bolts or screws, and is to be used to isolate such conductor only when the other conductors are isolated.

Instruments

335 Every main switchboard and every emergency switchboard is to be provided with the instruments specified in 336 to 338.

336 Two-wire Direct-Current Systems

Where one generator is installed: one ammeter and one voltmeter.

Where more than one generator is installed, the generators not being arranged to run in parallel: for each generator installed, one ammeter and one voltmeter.

Where more than one generator is installed, the generators being arranged to run in parallel: an ammeter for each generator, and two voltmeters. A plug or a linked double-pole multiple-way switch is to be provided to enable one voltmeter to be connected to any one generator before the machine is connected to the busbars; and the other voltmeter is to be permanently connected to the busbars. For compound machines the ammeter is to be connected on the positive pole (i.e., the pole opposite to that to which the equaliser connection is made).

337 THREE-WIRE DIRECT-CURRENT SYSTEMS

Instruments as specified for two-wire systems, and, in addition, a voltmeter connected between the neutral and each outer busbar.

338 THREE-PHASE ALTERNATING-CURRENT SYSTEMS

Where only one alternating-current generator is installed, or where more than one alternating-current generator is installed, the generators not being arranged to run in parallel: for each generator, one voltmeter, and an ammeter in each phase conductor or one ammeter and a selector switch designed to permit the reading of the current in each phase.

Where more than one alternating-current generator is installed, the generators being arranged to run in parallel: a wattmeter, and an ammeter in each phase conductor or an ammeter and a selector switch designed to permit the reading of the current in each phase; for paralleling purposes, two voltmeters and a synchronising device, the latter comprising a synchroscope and lamps arranged for bright synchronising. A plug or a linked double-pole multiple-way switch is to be provided to enable one of the voltmeters to be connected to each phase of any one generator before the machine is connected to the busbars; and the other voltmeter is to be permanently connected to one phase of the busbars.

Instrument Scales

339 The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit; and the upper limit of the scale of every ammeter is to be approximately 150 per cent of the current rating of the circuit in which the ammeter is connected. Ammeters for use with direct-current generators which may operate in parallel are to be capable of indicating a reverse current of at least 15 per cent of the rated full load current of the generator.

Earth Testing

340 Every main switchboard and every emergency switchboard is, except where one pole or the neutral is solidly earthed, to be provided with suitable means for indicating the state of the insulation of the system.

341 Where an earth-indicating system using lamps is adopted, earth-indicating lamps are to be of the metal-filament type each not exceeding 30 watts. The system employing a single lamp is not to be used.

For the special requirement for ships carrying oil having a flash point below 150° F. (65·5° C.) *see* M 1510.

NOTE.—To facilitate comparison of the brilliance of earth-indicating lamps they should be of the same colour and size and should be placed not more than 6 inches apart.

Protection of Essential Services

342 Where the auxiliary machinery is entirely or almost entirely electrically driven, means are to be provided to ensure as far as is practicable a continuous supply of power to essential services.

343 Where two or more generators are required to run in parallel to supply the maximum load under sea-going conditions the protective devices are to be so arranged that in the event of the generators becoming overloaded the non-essential services are interrupted first, and the essential services are maintained by the generator or generators which remain in operation.

NOTE.—The operating or tripping circuits referred to in this paragraph should, where necessary, be arranged with auxiliary contacts or similar means to ensure that the generators are completely isolated when the circuit-breakers are in the off position.

For preference tripping systems the following settings are preferred:—

The over-current protection relays should preferably be set to operate at 150 per cent for main generator circuit-breakers and 110 per cent for preference tripping, expressed as a percentage of the rated current of the generator.

Where time-delays are fitted the preferred time-delays at the foregoing over-currents are:—

Main generator circuit-breaker ...	... 20 seconds
Third tripping circuit-breaker or relay	... 15 seconds
Second tripping circuit-breaker or relay	... 10 seconds
First tripping circuit-breaker or relay	... 5 seconds

Circuits to electrically-driven machinery essential for the preservation of perishable cargo should be included in the last group to be disconnected.

Over-Current Protective Devices

344 Devices for protection against over-current and short circuit are to be of the type shown in the following schedule:—

Current rating of generator or cable protected by device	Type of device to be used
Up to 200 amperes	Fuse or circuit-breaker
201 to 300 amperes	Fuse or circuit-breaker*
Above 300 amperes	Circuit-breaker

*It is recommended that a circuit-breaker be used in preference to a fuse.

Switches and Circuit-Breakers

345 Each switch, switch-fuse and circuit-breaker is to comply with the requirements of 346 to 361.

346 The maximum temperature rise of all current carrying parts, with the exception of coils and thermo-tripping devices is not to exceed the following values :—

Rating	Maximum Temperature Rise	
	Open Type	Totally Enclosed
Up to 100 amperes	36° F. (20° C.)	54° F. (30° C.)
101 to 2000 amperes	54° F. (30° C.)	54° F. (30° C.)
Above 2000 amperes	72° F. (40° C.)	72° F. (40° C.)

When the main contacts have an adequate and durable silver facing the permissible temperature rises may be increased by 18° F. (10° C.).

The temperature rise of thermo-tripping devices is not to exceed 288° F. (160° C.) as measured by thermo-couple.

347 The maximum temperature rise of operating coils is not to exceed the values shown in Table XXIII.

348 All stem connected switches are to have the contacts and hinges dowelled or otherwise locked to prevent their getting out of alignment by rotation on the panel.

349 The minimum number of connection nuts for each stud is to be two, but if a nut is required for clamping the part to the base, a third nut is to be supplied in addition.

350 Every switch is to be capable of breaking a load current 50 per cent in excess of its rated current at rated voltage, 100 times for switches rated up to 60 amperes, and 10 times for larger switches, and be capable of being put into service at the conclusion without injurious overheating.

351 Every circuit-breaker is to be so adjusted that it will open the circuit when a current flows equal to not more than twice the rating of the smallest cable or bare conductor it is installed to protect, provided that this requirement is not to apply to a motor circuit installed in accordance with M 505. Overcurrent settings are to be calibrated in amperes.

Note.—It is preferred that circuit-breakers should be set to operate at over-currents (expressed as a percentage of the current rating of the cable protected) in accordance with the appropriate item in the following schedule:—

	Current setting
Continuously rated circuits	125 per cent
Intermittently rated circuits	150 per cent
Steering-gear circuits and emergency circuits ...	200 per cent

352 Where reverse-current protection is provided the device is to operate at not more than 15 per cent of the rated full-load current of the generator with rated voltage across the potential coil, at any permissible temperature within the working range.

The action of the reverse-current mechanism is not to be rendered inoperative by a reverse current of excessive value provided the applied voltage is not reduced by more than 50 per cent. A fall of 50 per cent in the applied voltage is not to render the device inoperative, but it may alter the amount of reverse current required to open the breaker.

353 Every circuit-breaker rated at more than 15 amperes is to be of the free-handle type, and is to be provided with suitable means of adjustment for determining the current at which it is to open the circuit.

354 Every circuit-breaker is to be so constructed that, irrespective of the method of tripping and the conditions of load, it will when operated break the circuit effectually and without undue arcing.

355 Every circuit-breaker is to have a breaking capacity not less than the prospective short-circuit current at the point in the circuit at which it is installed unless it is backed up by a fuse of suitable Category of Duty or by a circuit-breaker with an instantaneous trip setting of not more than 90 per cent of the breaking capacity of the device protected. The back-up protection is to have a breaking capacity not less than the prospective short-circuit current at the point where it is installed. Reports of tests to establish the maximum breaking capacity of circuit-breakers are to be submitted for consideration when required.

356 Circuit-breakers are to be so arranged and placed that no inflammable material is endangered by their coming into action, and that the arc cannot reach earthed metal.

357 Where the current to be interrupted by a switch or circuit-breaker is of such magnitude as to cause damage to the contacts, suitable arrangements are to be made for the easy renewal of the damaged parts, without requiring the removal of the apparatus from its place.

358 The handles and operating mechanisms of switches and circuit-breakers are to be mechanically strong, and are to be so designed and arranged that the hand of the operator, when using the device,

cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit-breaker or the blowing of an adjacent fuse. If switches are enclosed, their handles are not to operate through unprotected slots.

359 Where switches are not fixed on a switchboard, the live parts are to be enclosed by covers of non-ignitable material. In positions in which they are liable to mechanical injury the covers are to be of rigid metal or are to be protected by a suitable guard. In other positions the covers may be either of rigid metal or non-conducting material. Metal cases are to be well clear of live parts, and where the switches are to operate at voltages exceeding 125 volts and are rated for currents exceeding 6 amperes, any parts of the cases which are adjacent to arcing contacts are to be lined with non-ignitable insulating material.

360 All switches fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be contained in weatherproof cases which are to be provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering these fittings are run.

361 Each circuit-opening device is to be so constructed and arranged that when placed in the off position it cannot accidentally move sufficiently to close the circuit.

Fuses

362 Every fuse fitted on a switchboard, section board or distribution fuse-board is to comply with the requirements of Appendix 5 and with 363 to 368, and the choice from the categories referred to in the Appendix is to be made with regard to the prospective short-circuit current and the total output of the generators feeding the circuit in which the fuse is connected.

363 Details of the construction and tests for rupturing capacity, temperature rise and insulation resistance of fuses are to be submitted for approval and only approved types of fuse are to be installed on switchboards, section boards and distribution fuse-boards.

364 Each fuse is to be permanently and indelibly labelled with the current carrying capacity of the circuit or generator protected by it and with the appropriate approved size of fuse or replaceable element.

365 The current rating of a fuse-element is not to exceed the current rating of the smallest cable in the circuit protected by it, provided that this requirement is not to apply to a motor circuit in accordance with M 505 and in the case of steering gear circuits the minimum fusing current is to be not less than twice the full load current of the motor. Table XX gives approximate fusing currents for wires of copper and standard eutectic tin-lead alloy.

366 Every fuse is to be provided with a suitable non-ignitable insulating fuse-carrier of such form as to protect a person handling it from shock and burns, except where suitable insulated detachable handles are provided or the arrangements are such that, in distribution fuse boards, a switch connected on the live side of the fuse is fitted adjacent thereto and a lid or door is provided to protect the fuse from unauthorised access.

367 Effectual provision is to be made for retaining in position all fuses subjected to vibration or shock.

368 Where fuses are not fixed on a switchboard they are to be grouped on section boards or distribution fuse-boards, or are to be contained within cases conforming in all respects to the requirements laid down in 370 to 378.

369 Fuses are not to be placed in socket-outlets or ceiling roses.

Section Boards and Distribution Fuse-boards

370 Section boards and distribution fuse-boards are to be constructed in accordance with 304 to 318, so far as they are applicable, and the fuses fitted on such boards shall conform to 362 to 369.

371 Every section board and distribution fuse-board is to be contained within a protecting case, unless of such size that it is contained in a separate compartment or space in the ship. Cupboards or compartments containing switchboards are to be composed of, or lined with, non-ignitable material.

372 Cases are to be of ample mechanical strength and rigidity and metal cases are to be protected from corrosion. Ample space for wiring is to be provided.

373 Cases are to be of metal, except in passenger and similar accommodation, or in the vicinity of the compasses, where they may be of wood.

374 Where the case is of metal the minimum distance in air between live metal and the case is to be not less than ½-inch, independent of any displaceable insulation, whether bushing or barrier, and not less than ¾-inch when measured over the surface of any non-displaceable insulation. The clearance between arcing contacts or fuses and unlined cases is to be such that operation within the rating of the switch, fuse or circuit breaker can be carried out satisfactorily.

375 All wood cases are to be lined with non-ignitable insulating material. The lining is to be clear of live parts by not less than ½-inch.

376 Cases not provided with backs forming an integral portion thereof are to have a non-ignitable insulating shield between their contents and the bulkhead or any other structure to which they are fixed.

377 Where glass fronts are provided, the glass is to be of the wired type and the fronts are to clear all live parts by not less than ¾-inch. Where the boxes are of metal, such fronts may be regarded as insulating shields.

378 Cases fixed in positions exposed to the weather, to drip, or to an excessively moist atmosphere, are to be weatherproof and provided with cable glands or bushings, or be adapted to receive screwed conduit, according to the way in which the cables entering these fittings are run.

Joint and Junction Boxes

379 Joint and junction boxes are to be constructed wholly of durable, non-inflammable, non-absorbent materials, and all insulation is to be of permanently high electric strength and insulation resistance. The live parts are to be so arranged, by suitable spacing or shielding with non-inflammable insulating materials, that conductors of opposite polarity or different phase cannot readily be short-circuited. If used in damp situations, such boxes are to be weatherproof.

380 All metal cases are to be earthed.

Section 4

DISTRIBUTION

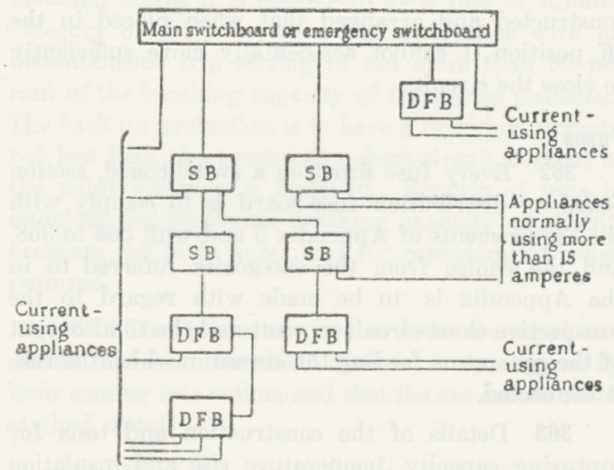
401 Every distribution fuse-board is to be connected either directly or *via* a transformer to one of the following:—

The main switchboard or emergency switchboard.

A separate way on a section board.

One or more other distribution fuse-boards either by looping-in to their busbars or in the form of a ring main. Fuse-links or disconnecting links may, if desired, be inserted in these connecting circuits. The circuit feeding such an arrangement of distribution fuse-boards is to be connected to one way of the main switchboard, the emergency switchboard or a section board. Where a reduction is made in the cross-sectional area of a conductor, protection is to be provided in compliance with the requirements of M 618.

NOTE (1).—The sequence shown in the following diagram is recognised as standard. The number of intermediate boards intervening between the final sub-circuit and the main switchboard or emergency switchboard will depend upon the size and disposition of the installation.



NOTE (2).—Section boards control the supply to other section boards, distribution fuse-boards, or devices normally consuming more than 15 amperes. Distribution fuse-boards comprise fuses or other overload protective devices for supplies only to final sub-circuits normally consuming not more than 15 amperes.

Protection Against Excess Current

402 Throughout an installation every circuit is, except as prohibited under 405, to be protected on each insulated pole by a fuse or circuit-breaker.

Control of Circuits

403 Every outgoing circuit from a section board or a distribution fuse-board is to be controlled by a fuse or other overload protective device on each insulated pole, and every two-wire circuit rated at more than 100 amperes is, in addition, to be controlled as a minimum by a switch on one insulated pole.

404 Every three-phase three-wire circuit is to be controlled by a triple-pole linked circuit-breaker with an over-current release in each insulated pole or, alternatively, by a fuse in each insulated pole and for every circuit rated in excess of 60 amperes, by a triple-pole linked switch.

405 A fuse, non-linked switch, or non-linked circuit-breaker, is not to be inserted in that pole of the circuit which is either earthed or derives its polarity from an earthed conductor, but an isolating link securely fixed to its terminals by bolts or screws may be fitted for testing purposes.

NOTE.—Requirements for the control of outgoing circuits from main switchboards and emergency switchboards are contained in M 329 to M 332.

Earth Return

406 Only ships having metal hulls may be wired on the single-conductor system: hence such system shall not be used on composite ships.

Earthing of Neutral

407 Where the distribution is effected on the three-wire direct-current system, or three-wire or four-wire three-phase alternating-current system, whatever the voltage of supply, the neutral may, if desired, be earthed.

408 Where the voltage exceeds 250 volts across the outer conductors of a three-wire direct-current system, the middle-wire is to be solidly and permanently earthed at one point only.

Earthing Connections

409 Every earthing lead (other than those provided for in 410) is to be of stranded or solid phosphor bronze or high-conductivity copper, and is to be protected wherever exposed to the likelihood of mechanical damage, and also, where necessary, against corrosion, particular attention being given in these respects to the point of connection to the hull of the ship. The nominal cross-sectional area of such earthing lead is to be not less than 0·007 square inch for every 50 amperes of working current, provided that its sectional area is in no case less than 0·0045 square inch and is the same as the sectional area of the working conductor for all sizes up to 0·007 square inch. Its sectional area need not exceed 0·1 square inch. The nominal cross-sectional area of every phosphor-bronze earthing lead is to be such as to provide a current-carrying capacity not less than that which would be required for a copper earthing lead.

Where connections are made to conduit or pipes they are not to be made by means of the screw or screws which are used for tightening the clamp to the pipe or by means of saddle fixing screws. Provision is to be made for attaching the earthing lead to the clamp by means of an independent screw or by sweating.

NOTE.—Where earthing leads are exposed to the weather it is preferred that phosphor bronze be used.

410 Every conductor used to carry the working current of a circuit to the ship's structure on the single-conductor system of distribution is to have a cross-sectional area not less than that of the corresponding conductor of the insulated portion of the circuit.

411 Every connection to the ship's structure is to be in an accessible position, and is to be secured by a brass screw of not less than $\frac{3}{8}$-inch diameter used for this purpose only. Where a cable socket is not used (*see* M 901) the wires are to be formed into a hook and placed under a tinned brass washer. In all cases care is to be taken to ensure bright metallic surfaces at the contact areas immediately before screwing up.

Two-Wire Circuits above 250 Volts

412 Where the voltage exceeds 250 volts, the conditions detailed in 413 to 416 are to be observed.

413 Motors only are to be supplied at such higher voltages and no portable motor of any size nor direct-current motor having a rating less than one brake horse-power nor alternating-current motor having a rating less than one quarter horse-power shall be so supplied.

414 All exposed metalwork, other than that designed to be live, is to be effectually connected to earth.

415 All apparatus is to be so constructed, enclosed, and protected, that there shall be no danger of shock in the ordinary handling thereof.

416 If the primary means of isolation is remote from the apparatus supplied, an additional means of isolation is to be installed adjacent to the apparatus, or, alternatively, provision is to be made for locking the primary means of isolation in the off position.

NOTE.—Requirements for generators, motors, and cables, for voltages exceeding 250 volts are contained in M 2, M 9 and M 12.

Three-Wire Circuits above 250 Volts

417 Where three-wire distribution is employed and the voltage across the outer conductors exceeds 250 volts, the voltage between any two points in one space or compartment where portable fittings, appliances, or accessories are likely to be used is not to exceed 250 volts, unless the fittings, appliances, or accessories, between which there may be a higher voltage, are so situated that they cannot be brought within 6 feet of each other.

Alternative Lighting in Engine Rooms, etc.

418 In machinery spaces (including boiler rooms), shaft tunnels and steering gear compartments, and in the corridors and stairways leading to the boatdecks of passenger ships, alternate groups of lamps are to be supplied from circuits so arranged that the melting of any one fuse-element (other than a fuse-element on the main switchboard) will not leave these spaces in darkness.

Emergency Supply

419 Where the Ministry of Transport require an emergency supply to be provided, it is to be adequate in amount, and so disposed as to meet all requirements concerning safety imposed by the Ministry of Transport. Emergency circuits are to be connected direct to a change-over switch or switches, which are to be fitted on the emergency switchboard only, to enable such circuits to be quickly transferred from the ordinary source of supply to the source of emergency supply. Where an emergency battery is installed, an indicator is to be provided and is to be arranged to show whether the battery is in service. The indicator should preferably be mounted on the main switchboard.

Shore Connections

420 Where provision is required for a supply of electrical energy from a source on shore or other external source, a suitable connection box or boxes is to be fitted in a position convenient for the reception of portable cables from the external source, and containing terminals of ample size and of such form as to enable the conductors to be effectually clamped therein. The terminals are to be connected to the main switchboard by suitable cables permanently fixed. Where the cables are of 300 amperes capacity or less they are to have, at the incoming point on each pole, fuses and a linked switch or a circuit breaker of appropriate size. The cables are to be connected to the main switchboard through a switch on each pole. Where it is intended to supply current from the ship's generator to outside sources, a circuit breaker or a switch and fuse is to be fitted on each pole at the switchboard.

Where a busbar voltmeter is not provided, a pilot lamp is to be installed to indicate when the shore supply is connected.

421 Where the arrangements referred to in 420 are made in connection with a three-phase alternating-current supply, a phase-sequence indicator is to be mounted adjacent to the terminals designed for connection to the external source, the indicator being so connected that the phase-sequence of the incoming supply may be checked, and connections corrected if necessary, before any part of the ship's three-phase installation is energised.

Interference with Magnetic Compasses

422 Generators, motors, secondary batteries, control gear, resistors, electric cables, and other apparatus producing an external magnetic field when in use, are to be fitted at such distances from the compass bowl (having regard to the strength of field set up and the facilities for its conduction by magnetic materials) as will reduce the magnetic field produced by such apparatus to a negligible value thereat.

NOTE.—It is recommended that the devices and apparatus referred to in this paragraph should, unless known to be safe at a lesser distance, never be less than 10 feet distant from any magnetic compass.

423 A single-conductor direct-current circuit is not, in any instance, to be fitted within 30 feet of standard and steering compasses. In order that the lead and return currents in such circuit shall neutralise one another in two-conductor systems, cables in the vicinity of the compass are preferably to be twin; and single-core cables are to be fixed as close to one another as possible, and are to be equidistant from the compass throughout their length. Cables within the compass binnacle are to be as short and direct as possible; and where such cables are single-core, they are to be twisted together and are not to be coiled into spiral loops.

424 The current input of incandescent electric lamps employed for illumination of the compass card is not to exceed 0·6 ampere. Such lamps are to be so placed that no live part is less than 7 inches from any part of the magnetic system of the compass.

425 Careful tests are to be made during the adjustment of the compasses. The effect of switching on and switching off circuits, motors, and other electro-magnetic apparatus near the compasses is to be noted and careful records kept of any errors observed, whether corrected or not.

Navigation Lights

426 Each navigation light is to be separately wired from a special distribution fuse-board which is not to supply any other group. This distribution fuse-board is to be placed in a position accessible to the officer of the watch.

427 Each navigation light on a single-conductor system or a two-conductor earthed system is to be controlled by a fuse and a single-pole switch on the insulated pole, and every such light on a two-conductor insulated system is to be controlled by a fuse on each pole and a double-pole linked switch. These switches and fuses are to be fitted on the special distribution fuse-board referred to in 426.

428 Each navigation light is to be provided with an automatic indicator to give an aural and/or visual signal in the event of extinction of the light. Where a visual signal is not employed, the source of supply to the aural device is to be a primary or secondary battery. Where a visual signal is employed and failure of the indicator lamp would result in interruption of the supply to the navigation lights, means are to be provided for bridging the indicator contacts until the faulty lamp is replaced.

NOTE.—This paragraph does not apply to tugs, trawlers, or fishing and similar small ships.

The indicator referred to in this paragraph may, if desired, be combined with the special distribution fuse-board specified in 426.

The efficiencies of navigation lamps are based on a voltage drop in series indicating devices up to 3 per cent of the rated voltage of the circuit.

429 In the event of failure of the circuit supplying the navigation lights, it is to be possible on the bridge to change them over to an alternative circuit.

430 The fixed wiring to each navigation light is to terminate at a watertight plug and socket or preferably at a watertight connection box adjacent to the lantern, and the lamp is to be provided with a short length of flexible cable, securely anchored to the lantern.

431 On single-wire systems every navigation light is to be wired from the distribution fuse-board with two insulated conductors, the earth connection being made at an earth point in the distribution fuse-board.

432 All switches and fuses between the final distribution fuse-board and the main switchboard are to be clearly marked to indicate that they control the supply to navigation lights.

Control of Electric Lift Circuit

433 Circuits which supply current to the motor operating an electric lift or hoist are not to be included in any twin or multicore trailing cable used in connection with the control and safety devices of the lift or hoist. They are not to be connected to a distribution fuse-board controlling final sub-circuits for lighting unless the maximum current (including the starting or accelerating current) of the motor is less than 20 per cent of the total rating of the fuse-ways on the distribution fuse-board, and unless the fuse-way of the motor circuit is clearly labelled.

434 A twin or multicore trailing cable which is used in connection with an electric lift or hoist, and which incorporates any conductor of any circuit operated at the supply voltage, is not to include any conductor of an electric bell or similar signalling circuit which is operated at reduced voltage from the supply system, or which is energised from another source.

Steering Gear

435 Where the steering gear is operated by two independent machines both being driven by electric or electro-hydraulic power and an approved alternative means of steering is not provided they are to be supplied by two independent circuits. Each circuit is to be connected direct to the main switchboard.

The cables for each circuit are to be led by independent routes so that, as far as practicable, damage to one does not involve the other.

Control of Oil Fuel Pumps

436 Where the motive power of oil fuel transfer and unit pressure pumps is an electric motor, provision is to be made for stopping the motor from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated as well as in the compartment itself.

Control of Ventilating Fans and Blowers

437 All power ventilation fans, except fans for machinery space and cargo hold ventilation, are to be fitted with master controls so that, in the event of fire, they may be stopped from either of two control stations which are to be situated as far apart as practicable. For machinery space ventilation one master control, in addition to that provided at the main switchboard, is to be provided, operable from a position outside the machinery space.

Provision is also to be made for stopping from positions outside the machinery spaces other fans or blowers situated within the compartment.

Control of Automatic Sprinkler Systems

438 Where the power for sea-water pumps, air compressors and automatic alarms is electric there is to be no switch in the circuit other than that at the switchboard. The switch is to be clearly labelled.

Transformers for Power and Lighting

439 Transformers in accommodation spaces are to be arranged for air natural cooling. In machinery spaces they may be arranged for air cooling or be oil immersed. Wherever situated the transformers are to be of drip-proof construction.

440 Transformers are to comply with the requirements of Appendix 10.

441 The compartments in which transformers are placed are to be well ventilated and free from the likelihood of an accumulation of inflammable gases. The transformers are to be clear of all inflammable material, easily accessible, and not exposed to risk of mechanical injury or to damage from water, steam or oil. Cupboards or compartments containing transformers are to be composed of, or lined with, non-ignitable material.

442 Oil-cooled transformers are to be preferably of the conservator type, and be so designed that, under all conditions with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical, they are to operate without the risk of spilling oil. Means are to be provided to permit breathing through a suitable dehydrator.

Drip trays or other suitable provision is to be made to deal with loss of oil due to damage or other causes.

An oil gauge marked with normal oil level is to be fitted.

443 All windings of air-cooled transformers are to be treated to resist moisture, sea-air and oil-vapour.

444 The voltage regulation at full-load and unity power factor of transformers used to supply lighting circuits is not to exceed 2½ per cent for transformers rated at 5 kVA per phase and over or 5 per cent for transformers rated at less than 5 kVA per phase.

It is preferred that adjusting tappings should not be provided.

445 A rating plate is to be fixed to each transformer giving details of rating.

446 Where essential services are supplied two or more transformers are to be provided, together with appropriate switchgear so that in the event of one transformer being out of commission the remaining unit or units are capable of supplying the essential services.

Section 5

FINAL SUB-CIRCUITS

Arrangement

501 Every final sub-circuit is to be connected to a separate way on a distribution fuse-board or section board, or to the main switchboard or emergency switchboard.

502 A final sub-circuit having a rated capacity not exceeding 15 amperes may supply any number of points up to ten. A final sub-circuit having a rated capacity exceeding 15 amperes is not to supply more than one point.

503 In cornice lighting, panel lighting, and electric signs, where lampholders are grouped in close proximity to each other and are connected to the circuit without flexible cords, each lampholder is not, for the purposes of 502, to be deemed to be one point. In these circumstances more than ten lampholders

may, if desired, be connected to a final sub-circuit, provided that the maximum working current in such sub-circuit does not exceed 10 amperes.

NOTE.—Where a circuit for a pilot lamp in connection with a current-using appliance is connected through a local fuse or fuses to the final sub-circuit supplying the appliance, such pilot-lamp is not, for the purposes of these Rules, deemed to be a final sub-circuit.

Protection against Excess Current

504 Every final sub-circuit is, except as prohibited under M 405, to be protected on each insulated pole by a fuse or circuit-breaker with overcurrent release in each insulated pole.

505 Where the starting or accelerating current of a motor considerably exceeds the rated full-load current, overcurrent protection is to be provided for the motor circuit, but such protection is to be so designed as to allow an excess current to pass during the normal accelerating period of the motor concerned.

506 A fuse smaller than one rated for a normal working current of 3 amperes need not be inserted in any final sub-circuit.

507 In every installation the lighting circuits are to be supplied by final sub-circuits separate from those for heating and for power requirements. This requirement does not preclude the supply of cabin fans from lighting circuits.

508 All lighting circuits in cargo spaces are to be controlled by a double-pole linked switch located outside such spaces. Provision is to be made for the complete isolation and for the locking in the off position of the control of every such circuit.

Section 6

CONDUCTORS

Standard Sizes

601 The sizes of conductors shown in Tables I, III, and VII, are recognised as standard for ship installations.

Material

602 All conductors of cables are to be of annealed copper.

603 Where the insulating covering of the conductor of a cable is composed of vulcanised rubber, each wire is to be effectually and uniformly coated with tin free from all impurities, and the tinned conductor of the finished cable is to be capable of withstanding the tinning test set out in Appendix 7.

604 Where the insulating covering of the conductor of a cable is cambric impregnated otherwise than with a bituminous-base compound, an effective separating tape is to be inserted between the cambric and the lead-alloy sheathing, and, where the conductor is not tinned in compliance with 603, also between the cambric and conductor.

605 All busbars, busbar connections, and bare conductors are to comply with the requirements of the appropriate paragraphs in Appendix 7. Aluminium is not to be used.

Miniumum Size of Conductor

606 The smallest conductor for fixed wiring is to have a nominal cross-sectional area of not less than 0·0015 square inch, except as permitted by M 719 for communication circuits.

Maximum Size of Single Wire

607 All conductors of cables having a nominal cross-sectional area exceeding 0·003 square inch (1/·064 in.), except the conductors of mineral-insulated copper-sheathed cables, are to be stranded.

Current Carrying Capacity of Cables

608 Every conductor of a cable (other than a flexible cord or flexible cable, for which *see* M 8) is to be capable of carrying, without the respective ratings set out in Tables I to V(a) inclusive and Table XXVIII being exceeded, the maximum current which will normally flow through it, subject to the provisions of 609 to 613.

609 For final sub-circuits a diversity factor is not to be applied.

610 For circuits other than final sub-circuits a diversity factor may be applied, provided that the known or anticipated conditions are suitable for the application of diversity.

NOTE.—It is impossible to specify in these Rules the value of the diversity factor for every type of installation. For the application of diversity to circuits supplying cargo-winches, cranes, windlasses, and capstans, see 615.

611 For an electric motor, the maximum current is to be deemed to be the full-load rated current of the motor, and, unless the actual current be known, is to be taken to correspond to the values given in Table

XXI for the types referred to therein. For motor outputs between those shown in the Table, the full-load current is to be taken to be directly proportional to the output and is to be calculated from the next lower output given in the Table.

612 Where the load on a cable is intermittent, the cable is permitted to carry a larger current (subject to voltage drop) than if continuously loaded. Table VI gives the maximum permissible currents for half-hour and one-hour ratings. In no case is a shorter rating than one half-hour to be taken whatever may be the degree of intermittency.

613 In assessing the current rating of lighting points for the purpose of determining sizes of conductors, every lampholder is to be deemed to require a current equivalent to the maximum load which is likely to be connected to it, which is, except for the circuits described in M 503, to be assumed to be at least 60 watts, provided that where the lighting fitting is so constructed as to take only a lamp smaller than 60 watts the conductors may be assessed accordingly.

Circuits for Cargo-Winches, Windlasses, etc.

614 Cables for the motors of cargo-winches, cranes, windlasses, and capstans, are to be suitably rated for the duty intended, and, unless the duty is such as to require a longer rating, cables for winch motors may, if desired, be half-hour rated (subject to voltage drop) based on the brake-horse-power ratings of the motors. Cables for windlass motors and capstan motors are to be not less than one-hour rated (subject to voltage drop) based on the brake-horse-power ratings of the motors.

615 A diversity factor may, if desired, be applied in calculating the cross-sectional areas of cables supplying groups of cargo-winch motors or crane motors, subject to such factor being based on the proposed duty of the motors and on currents as required by Table XXII. Such cables are to be capable of carrying continuously (subject to voltage drop) the current calculated by applying the diversity factor to the total connected load of winch motors and crane motors. Where the cables feeding winch motors and/or crane motors supply, in addition, other equipment, the current upon which the size of the cable is based is to be computed with due regard to the coincidence of the various loads.

Equaliser Connections

616 Every equaliser connection for use with flat-compounded generators is to have a cross-sectional area of at least 50 per cent of the cross-sectional area of the positive and negative connections to the generator.

NOTE.—To assist proportionate sharing of the load by parallel connected generators, it is recommended that where the lengths of the connections or the rated sizes of the generators are different the cross-sectional areas of the equaliser connections should be so graded as to ensure that the voltage drop in all of them is equal at full load.

Voltage Drop

617 The size of conductors is to be so selected that the fall of voltage between the main switchboard busbars and any and every point on the installation, when the conductors are carrying the maximum current under the normal conditions of service, does not exceed 6 per cent of the voltage at the busbars for power, heating and lighting circuits, and 1 volt plus 1 per cent of the voltage at the busbars for radio apparatus mains when carrying the main and battery charging loads simultaneously.

NOTE.—Where an independent charging circuit is provided for the radio battery, the last words of this paragraph apply only to the radio apparatus mains.

Relative Sizes of Conductor and Fuse-Link

618 In each circuit every cable is to have a current rating not less than that of the fuse-element (or the adjustment of the circuit-breaker) protecting the circuit. Where a reduction in cross-section is made to a conductor, e.g., at an extension or branch thereof, the smaller conductor is to be protected locally by a circuit-breaker or fuse-element of the appropriate rating (*see* M 351, M 365 and Tables I to VII) except where the adjustment of the circuit-breaker or the rating of the fuse-element protecting the larger conductor does not exceed the rating of the smaller conductor.

Section 7

INSULATION AND PROTECTIVE COVERING OF CABLES

Types of Cables

701 Cables may be single-core, twin or multicore. Only the types specified in 702 to 706 may be used.

702 Vulcanised - rubber - insulated cables and cables having fire-resisting insulation consisting of an inner layer of vulcanised natural rubber and two

layers of polychloroprene (e.g., Neoprene) compound (R.N.N. type), either :—

taped, braided and compounded; or

taped and lead-alloy-sheathed (with, if desired, braiding over the lead); or

taped, lead-alloy-sheathed and armoured (with, if desired, braiding over the armour); or

polychloroprene-compound-sheathed (H.R. type); proofed cotton taped, braided and compounded with fire-resisting compound; or

tough-rubber-sheathed in sizes up to and including 7/·036 in. (0·007 square inch).

703 Impregnated - paper - insulated cables and varnished-cambric-insulated cables, either :—

lead-alloy-sheathed (with, if desired, braiding over the lead); or

lead - alloy - sheathed and armoured (with, if desired, braiding over the armour).

704 Varnished - cambric - insulated, polychloroprene-compound-sheathed, taped, braided, and fire-resisting compounded cables.

705 Mineral-insulated copper-sheathed cables.

706 Where it is desired to use types of cables insulated otherwise than specified in 702 to 705 sample lengths are first to be submitted for approval, each sample being accompanied by a report from a recognised testing authority regarding the behaviour, properties, and life, of the insulating materials employed.

707 Twin-core and three-core cables are to be circular, i.e., flat-sided cables are not to be used.

Vulcanised-Rubber-Insulated Cables

708 Vulcanised-rubber-insulated cables are to be insulated with two or more layers of vulcanised rubber (except where the insulation is applied by the extrusion process, in which case it may be applied in one layer). Fire-resisting cables are to be insulated with one layer of vulcanised rubber and two layers of polychloroprene compound (R.N.N. type). Except in single-core polychloroprene-compound-sheathed cables (H.R. type) and all tough rubber-sheathed cables, the insulated cores are to be covered with a helical binding of a high-quality cotton tape proofed on one side with rubber and applied, before vulcanisation, with a suitable overlap. The whole is to be vulcanised together and is to form a compact homogeneous body; it is not to be possible to separate the layers of rubber, but the tape is to be removable without tearing the rubber. The thickness of the insulation at any point is not to fall below the value stated in the appropriate Table VIII or IX by more than 5 per cent plus 0·005 in. The thickness of the insulation arrived at by taking the average of a number of measurements is to be not less than the value stated in the appropriate Table.

The insulation is to comply with the requirements of Appendix II.

NOTE.—R.N.N. types are not supplied with tough rubber sheaths.

709 Braided cables are to have a fibrous braiding, thoroughly impregnated with a preservative compound of such a nature as not to have any deleterious action on the rubber or armouring as the case may be. The finish of the braiding is to be smooth and uniform.

710 The interstices between the cores of twin and multicore rubber-insulated cables are to be filled with textile material or rubber and a rubber-proofed cotton tape is to be applied with a definite overlap over the laid-up and filled cores.

711 Tough-rubber-sheathed cables are to have the rubber-insulated core or cores surrounded by a continuous close-fitting sheath. For twin and multicore cables the internal surface of the sheath is to fit the cores so as to fill the interstices. The sheath is to be capable of offering a high degree of resistance to mechanical damage. The thicknesses of insulation and sheathing are to be in accordance with the appropriate Table X or XI. The tolerances on the thickness of insulation are to be as in 708 and the thickness of the sheath at any point is not to fall below the value stated in the appropriate Table by more than 5 per cent plus 0·01 in. The thickness of the insulation arrived at by taking the average of a number of measurements is to be not less than the value stated in the appropriate Table.

Impregnated-Paper-Insulated Cables

712 Impregnated-paper-insulated cables are to be insulated with layers of paper impregnated with a chemically neutral insulating compound. The paper is to be manufactured from chemical wood-pulp fibre and is to be uniform in texture, strong, long fibred, free from imperfectly pulped materials, metallic particles or deleterious substances. It is not to contain mechanical wood, straw, esparto, or any other low-grade fibrous materials. The thickness of the insulation is to be in accordance with the appropriate Table XIII or XV.

713 The insulated cores of multicore impregnated-paper-insulated cables are to be laid up with a suitable lay, the interstices are to be filled with paper or jute, and the cable is to be sheathed with lead alloy, in accordance with 720 and 721.

Polychloroprene - Compound - Sheathed Cables (H.R. type)

714 The cores are to be insulated in accordance with 708 and the sheath is to consist of a fire, oil and weather-resisting tough rubber-like polychloroprene compound (e.g., Neoprene) which is to form a continuous close-fitting tube. For twin and multicore cables the internal surface of the sheath is to fit the cores so as to fill the interstices.

The sheath is to be taped with a high-quality proofed cotton tape applied with a definite overlap, cotton braided and treated with a suitable fire-resisting compound.

The thicknesses of insulation and sheathing are to be in accordance with the appropriate Table VIII or IX.

The tolerances on the thickness of insulation are to be as in 708 and the thickness of the sheath at any point is not to fall below the value stated in the appropriate Table by more than 5 per cent plus 0·01 in. The thickness of the insulation arrived at by taking the average of a number of measurements is to be not less than the minimum value stated in the appropriate Table.

Special H.R. Type Cable

715 H.R. type cable is to consist of a rubber insulated core having a sheath of special oil-resisting rubber compound, varnished-calico taped and braided and treated with a flame-resisting compound. Suitable type tests are to be carried out and the results submitted for consideration. Only approved makes are to be used.

Varnished-Cambric-Insulated Cables

716 Varnished-cambric-insulated cables are to be insulated with layers of suitable high-quality varnished-cloth tape or strip, free from wrinkles, blisters, and other imperfections. A viscous, non-drying, and insulating compound is to be used for lubricating and sealing the layers of the varnished cambric. The compound is to be of a mineral base and is not to dry out or deteriorate. The compound is not to drip from the end of a three-foot length of the cable when suspended in a vertical position for 48 hours at a temperature of 170° F. (77° C.). The thickness of the insulation is to be in accordance with the appropriate Table XIII, XIV or XV.

717 The insulated cores of multicore varnished-cambric-insulated cables are to be laid up with a suitable lay, and the interstices are to be filled with impregnated jute or other suitable filling material.

718 The insulated cores are to be lead-alloy-sheathed or sheathed with polychloroprene compound which is to be oil-resistant and resistant to moisture absorption and to form a continuous close-fitting tube.

Polychloroprene-sheathed cables are to have the insulated core wrapped with a helical binding of cotton tape applied with a definite overlap prior to sheathing and after sheathing are to be taped, cotton braided and treated with a suitable fire-resisting compound.

The thickness of insulation and sheathing are to be in accordance with the appropriate Table XIII, XIV or XV.

Cables for Communication Circuits

719 Cables used for the purpose of internal communications are to be one or other of the types specified in 702 to 706 (*see* M 1806 and M 1807). The construction of such cables is to be in accordance with the relevant requirements of 708 to 718 except that the conductor may be 0·001 square inch (1/·036 in.) and the dimensions in accordance with Table XII. The tests are to be the same as for 250 volt cables.

Lead-Alloy Sheathings

720 Lead-alloy-sheathed cables are to be provided with a closely fitting sheath of uniform thickness, free from flaws, and having a smooth exterior surface. The metal of the sheath is to be of alloy A, alloy C or alloy E specified below.

Alloy	Composition (percentage by weight)						
	Tin		Cadmium		Antimony		Lead
	Min.	Max.	Min.	Max.	Min.	Max.	
Alloy A	1.8	2.2	—	—	—	—	The remainder
„ C	0.35	0.45	0.12	0.18	—	—	
„ E	0.35	0.45	—	—	0.15	0.25	

The lead used in these alloys is to have a lead content of not less than 99·9 per cent, and the impurities, including zinc and bismuth, are not to

exceed 0·1 per cent. Zinc is not to be present in an amount exceeding 0·002 per cent, nor bismuth in an amount exceeding 0·05 per cent. No scrap is to be used other than that derived from the cable maker's own manufacture.

721 The radial thickness of lead alloy sheathing is not to fall below the value specified in the appropriate Tables VIII, IX and XXIX by more than 5 per cent plus 0·005 in. The values specified in Table XXIX are to be applied in the case of cables for which dimensions of lead sheath are not specified in other relevant Tables. The values specified in Tables XIII and XV are minima.

Armouring

722 Armoured lead-alloy-sheathed cables are to have over the sheath a layer of hessian tape or other suitable material impregnated with a moisture-resisting preservative compound. On the bedding is to be applied an armouring of annealed steel tape or annealed and galvanised steel wire. The wires are to have a uniform lay of approximately 10 times the diameter of their pitch circle for wires exceeding 0·08 inch diameter, and of approximately 8 times the pitch circle diameter for wires of 0·08 inch diameter and smaller sizes. The armouring is to be so applied as to present a uniform cylindrical exterior surface. The diameter of armouring wire is to be as specified in Tables VIII, IX and XVI, and the thickness of the bedding, measured before the armouring is applied, is to be in accordance with Table XVI.

Multicore Cables

723 All the stipulations contained in these Rules relating to quality, dimensions, and tests, of single-core cables are, so far as they apply, to govern the construction of twin and multicore cables.

Contactor Coil and Highly Inductive Circuits

724 The insulation of cables for highly inductive circuits such as contactor operating circuits for winches, windlasses, capstans, steering gear and the field circuit of electro-magnetic couplings shall, as a minimum, be 660-volt grade.

Mineral-Insulated Copper-Sheathed Cables

725 The thickness of insulation and nominal overall diameters of mineral-insulated copper-sheathed cables are to be in accordance with Tables XXVI and XXVII.

The insulation, unless otherwise approved, is to consist of compressed magnesium oxide, which shall form a compact homogeneous body.

Testing and Inspection

726 The prescribed tests and inspections are to be made at the place of manufacture prior to despatch and may be required to be carried out under the supervision of the Surveyor; but, in the event of any of the material proving unsatisfactory in the course of being installed in ships, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing.

Tests of Dielectric of Cables

727 A voltage test is to be carried out on all cables at approximately room temperature with alternating current of sine wave form at a frequency between 25 and 100 cycles per second, and the root mean square of the voltage is to be as stated below for the appropriate grades of cable and maintained continuously at the full voltage for 15 minutes. The voltage test is to be made on the insulated core at the manufacturer's works after the core has been immersed in water for not less than 12 hours, and while still immersed, except that metal sheathed cables need not be so immersed. The voltage is to be applied between the conductor and the water or metal sheath, which is to be earthed, and between the conductors of twin and multicore cables.

Voltage Tests on Cables

Insulation	Grade	A.C. Test voltage
	volts	volts
Rubber, paper or varnished-cambric	250	1,500
Mineral	250	2,000
Rubber, paper, varnished-cambric or mineral ...	660	3,000
Paper or varnished-cambric	3,300	10,000

Alternatively vulcanised-rubber-insulated cables and fire-resisting polychloroprene insulated cables having conductors with a maximum cross-sectional area of 0·06 square inch may be spark tested in accordance with Appendix 8.

728 The insulation resistance between the conductor and the water in which the insulated core is immersed, or between the conductor and the lead sheath, for vulcanised-rubber-insulated cables is not to be less than the values given in Table XVII. For

cables having fire-resisting rubber-like insulation the insulation resistance is to be not less than 20 per cent of the values given in Table XVII. The temperature of the water is to be at or near 60° F. (15·6° C.). When the temperature is not exactly 60° F. (15·6° C.) the result obtained is to be corrected by the appropriate constant given below.

TEMPERATURE CORRECTION FOR INSULATION RESISTANCE

Temperature °F.	Multiplier constant	Temperature °F.	Multiplier constant
1	2	3	4
50	0·773	60	1·000
51	0·793	61	1·026
52	0·814	62	1·053
53	0·836	63	1·080
54	0·857	64	1·108
55	0·880	65	1·137
56	0·902	66	1·167
57	0·926	67	1·198
58	0·950	68	1·229
59	0·975	69	1·261
		70	1·293

The measurement of insulation resistance is to be made after one minute's electrification with direct current at not less than 500 volts.

729 Fire-resisting insulated cables are to comply with the following test.

A sample of untaped core, or alternatively of the finished cable, 24 inches long is to be clamped vertically in the middle of a three-sided metal screen approximately 36 inches high, 18 inches wide and 12 inches deep, with open front and closed top, the test being carried out in a room substantially free from draughts. The source of heat is to be a 20B Barthel burner with standard flame. With the base of the burner at 45 degrees to the line of the sample and the top of the burner 2 inches from the sample and approximately 3 inches from the lower end the fire-resisting properties are to be such that the following requirements are to be complied with :—

Time of application of the burner 60 seconds
Maximum period of burning after removal of the flame ... 60 seconds
Total length of core of cable decomposed ... ... 6 inches

Section 8

INSULATION AND PROTECTIVE COVERING OF FLEXIBLE CORDS AND FLEXIBLE CABLES

Types of Flexible Cords and Flexible Cables

801 Flexible cords and flexible cables other than those dealt with in 803 and in M 1516, are to be provided with one of the following protective coverings :—

Natural or self-extinguishing artificial silk braiding.

Glacé cotton braiding.

Fibrous braiding, thoroughly compounded.

Hard cord braiding in addition to fibrous braiding, thoroughly compounded.

Tough rubber sheathing applied directly to the laid-up insulated cores, with or without braiding.

802 Flexible cords and flexible cables are, except as provided in 803, to comply with such requirements of M 7 as are applicable.

803 Where the conductor temperature exceeds 150° F. (65·5° C.) but does not exceed 176° F. (80° C.), flexible cords for connection to immersion and other heaters are to be one of the following types :—

Flexible cords having the conductor insulated with heat-resisting rubber, asbestos roved, and cotton or asbestos braided overall.

Flexible cords having the conductor roved with asbestos, insulated with varnished cambric, asbestos roved, and cotton or asbestos braided overall.

Flexible cords having the conductor insulated with varnished cambric, asbestos roved, and cotton or asbestos braided overall.

NOTE.—The second and third types are suitable for use in dry situations only.

Current Rating of Flexible Cords and Cables

804 Flexible cords and flexible cables are to be capable of carrying, without the respective ratings set out in Table VII being exceeded, the maximum current which will normally flow through them.

Earth Continuity Conductor in a Flexible Cord or Flexible Cable

805 The earth continuity conductor in a flexible cord or flexible cable is to be insulated.

806 In a flexible cord having conductors of a nominal cross-sectional area of 0·0048 square inch or

less, the nominal cross-sectional area of the earth continuity conductor is to be equal to those of the current-carrying conductors.

807 In flexible cords having conductors of a nominal cross-sectional area greater than 0·0048 square inch, and in flexible cables, the nominal cross-sectional area of the earth continuity conductors is to be at least 0·0048 square inch and, in general, not less than one-half that of the current-carrying conductors.

Section 9

INSTALLING AND FIXING OF CABLES

Cable Ends and Sockets

901 Where substantial mechanical clamps are not used, the ends of every conductor having a nominal cross-sectional area exceeding 0·001 square inch (7/·044 in.) are to be provided with soldering sockets of such a size as to contain all the strands of the conductor.

902 Soldering fluids containing acid or other corrosive substances are not to be used.

Preparation of Cable Ends

903 When soldering or securing the ends of conductors to sockets or terminals, the insulation is not to be removed further than is necessary to allow the unreduced conductor to enter and completely fill the socket or terminal.

904 The braid, lead, or other covering over the insulation, including the tape in contact therewith, is to be cut back at least half an inch from the end of the insulation in cables up to half-inch diameter (measured over the insulation), and at least one inch from the end of the insulation in cables of greater diameter.

Sealing of Cable Ends

905 The exposed conductor and insulation of impregnated-paper-insulated cables and varnished-cambric-insulated cables is to be protected from moisture by being suitably sealed.

906 All the strands at the exposed ends of the conductors of impregnated-paper-insulated cables and varnished-cambric-insulated cables exceeding 0·0045 square inch sectional area are to be soldered together, where such exposed ends are not provided with cable sockets. The ends of the conductors of vulcanised-rubber-insulated cables in damp situations shall be similarly treated.

907 Where vulcanised-rubber-insulated cables operate under exceptional conditions of heat or moisture, or are subject to other deleterious agents, their exposed ends are to be effectually sealed.

NOTE.—Under all conditions the life of vulcanised-rubber-insulated cables is considerably increased if means are taken to exclude air from exposed rubber insulation and from the conductor where it emerges from the rubber insulation.

Selection of Cable Runs

908 Cables are, as far as is practicable, to be fixed in accessible positions, so chosen that the cables are not exposed to drip or accumulation of water or oil, steam or oily vapour, high temperatures from boilers, steam pipes, exhaust pipes, radiators, resistors, or other hot objects, or to avoidable risk of mechanical damage. Unless adequately protected, cables are not to be laid under machines or floor-plates. Cables in winch contactor houses are, as far as is practicable, to be kept clear of the outer steel plating (if any) and away from the heat of the resistors.

909 Cables, other than those specially designed for high temperatures, are not to be installed in any situation in which temperatures greater than the following are likely to be attained:—

Type of Insulation	Maximum Temperature of Cable Surroundings
Vulcanised Rubber ...	115° F. (46° C.)
Impregnated Paper ...	150° F. (65·5° C.)
Varnished Cambric ...	150° F. (65·5° C.)

910 A vulcanised-rubber insulated cable is not to be so bent that the radius of the inside of the bend is less than that given in the following schedule.

UNARMOURED		ARMOURED
Less than 1 inch overall diameter	More than 1 inch overall diameter	
4 times overall diameter of cable	6 times overall diameter of cable	6 times overall diameter of cable

This requirement does not necessarily apply to bends in small cables where entering fittings, terminal boxes, etc.

911 A cable (whether armoured or not) insulated with impregnated paper or varnished cambric is not to be so bent that the radius of the inside of the bend is less than eight times the overall diameter of the cable.

912 Where practicable, cables insulated with different types of dielectric are not to be bunched in a common clip, gland, conduit or duct.

Support and Protection

913 All cables (other than flexible cables connected to portable or movable fittings) are to be securely fixed in position in accordance with the requirements of 926 to 945.

914 Where exposed to risk of mechanical damage, cables are to be protected by sheet-iron plating or by heavy-gauge screwed steel conduit. The use of copper conduit is permitted. Copper conduit is not to be used in situations where it will be exposed to mechanical damage unless further protected by sheet-iron plating or other similar shielding.

915 In machinery spaces, galleys, bathrooms, and laundries, or where unavoidably exposed to the weather or to action of sea water, cables shall be either :—

lead-alloy-sheathed, with or without further protection; or

run in conduit; or

polychloroprene-compound-sheathed of the H.R. type; or

mineral-insulated copper-sheathed; or

varnished-cambric-insulated conforming with M 716 to M 718.

916 Cables entering cold-storage chambers are to pass directly through the walls or lagging of the chamber and are to be protected by a continuous tube flanged at each end; alternatively, they may pass through holes in wood of door frames, in which case the holes are to be sealed at both ends.

917 Cables fixed within cold-storage chambers are to be either :—

lead-alloy-sheathed, with or without armouring or braiding; or

polychloroprene-compound-sheathed of the H.R. type; or

mineral-insulated copper-sheathed.

They are not to be embedded in the walls or lagging, but are to be in full view throughout their length. The cables are to be carried on galvanised perforated plating so placed as to leave a space behind the back of the plating and the face of the chamber. As an alternative they may be supported on cleats made of porcelain, hardwood, or other non-metallic and non-hygroscopic material. Where the alternative method is adopted, precautions are to be taken to prevent the casual use of the cables as a means of suspension by the use of hooks placed around the cables.

All metal fixings, including fixing screws, used within a cold-storage chamber are to be galvanised.

918 Every metal-sheathed cable, whether armoured or not, is to have its lead-alloy sheath and armouring (if any) effectually earthed at both ends, provided that in final sub-circuits earthing may, if desired, be at the supply end only. Effectual means are to be taken to ensure that all metallic envelopes of cables are made electrically continuous throughout their length. All earthing connections are to be effected by means of clamps or soldered joints, or, alternatively, by glands specially designed for the purpose and forming part of joint boxes or similar fittings in which cables terminate.

919 Metal staples are not to be used for fixing any cable.

920 Flexible cords are not to be used for fixed wiring.

921 Cables of opposite polarity may, if desired, be bunched in conduit if carrying direct current, but cables carrying alternating current are always to be so bunched that the outgoing and return cables are drawn into the same conduit.

922 Cables carrying alternating current are to be kept separate from cables carrying direct current, and if on the same tray they are to be separately supported.

923 Cables shall not be led through or be in direct contact with oil fuel tanks.

924 Excessively large groups of cables are to be avoided.

925 Perforated plating supporting cables in machinery spaces is to be galvanised, or be provided with equally efficient protective coatings applied before erection.

Exposed or Cleated Wiring

926 Lead-alloy-sheathed cables, whether armoured or not, cables of the H.R. type, varnished-cambric-insulated polychloroprene-compound-sheathed cables and mineral-insulated copper-sheathed cables may, except as required by 914, be used without the further protection of casing, duct, or conduit, provided that they are secured by metal clips having smooth or rounded edges. All clips are to be firmly secured by screws of ample strength and are to be spaced in accordance with Tables XVIII and XIX. The clips are to be formed of non-rusting material or have a non-rusting finish.

927 Cables of all classes having a nominal cross-sectional area of 0·1 square inch and above may, if desired, be supported on cleats, which are to be spaced in accordance with Table XVIII and constructed of porcelain, hardwood, or other non-metallic, non-hygroscopic insulating material. The insulators are to have smooth or rounded edges that will not indent or damage the cable. In damp situations the supports and fixings of the insulators are to be of non-rusting material.

NOTE.—Attention is drawn to the possibility of corrosion of the lead-alloy sheathings of cables as a result of contact, in the presence of moisture, with oak and other woods.

Cables in Conduit

928 Any type of cable (other than the high-voltage cables specified in M 17 for luminous-discharge-tube installations) which complies with M 701 to M 706, may be enclosed in conduits, subject to the provisions of 929 to 937.

929 The conduits and conduit fittings are to comply with the requirements of 946 to 948.

930 Ventilating outlets suitably placed are to be provided, preferably at the highest and lowest points of the circuits, to allow circulation of air and to ensure that water cannot lodge in any part of the conduits.

931 The radius of any circuit is to be such as to permit of compliance with the requirements of 910 and 911 for the bending of cables. In any event the inner radius of the bend is not to be less than $2\frac{1}{2}$ times the outside diameter of the conduit; and elbows or tees, other than those of the inspection type, are not to be used except at the end of conduits immediately behind accessories or lighting fittings.

932 The ends of, and the outlets from, all conduits are to be bushed or so finished as to prevent abrasion of the coverings of cables emerging therefrom.

933 The saddles and fixings used for securing the conduits are to be of non-rusting material or have a non-rusting finish.

934 The conduits are to be earthed and are to be mechanically and electrically continuous across all joints.

935 Communication cables are not to be fitted in the same conduit as cables supplying lighting and power, unless the latter cables and/or the communication cables are either :—

lead-alloy-sheathed; or

polychloroprene-compound-sheathed of the H.R. type; or

varnished-cambric-insulated polychloroprene-compound-sheathed.

936 The number of cables in one conduit is to be such that they can be easily drawn in and, in any event, such that the sum of the overall cross-sectional areas of the cables does not exceed for the respective types the following percentages of the internal cross-sectional area of the conduit :—

Braided cables	50 per cent.
Plain lead-alloy-sheathed cables	40 per cent.
Lead-alloy-sheathed cables armoured, with or without braiding over the armour ...	30 per cent.

In every run of conduit facilities are to be provided as may be necessary to obviate the drawing of cables around more than one bend of 90 degrees or two diversions of 45 degrees in the run of the conduit.

937 Armoured cables and cables having fine wire braiding are not to be drawn into the same conduit as cables not similarly protected.

Cables in Wood Casing

938 Any type of cable which complies with M 701 to M 706 may be enclosed in wood casing, subject to the provisions of 939 to 945.

939 The casing is to be used only in dry situations and is not to be exposed to drip due to condensation or other cause.

940 The casing and capping are to be secured by screws, which for the capping are to be of brass and fixed on the outer edges only, and nails are not to be driven into the grooves of the casing for holding the cables or for any other purpose.

941 Where the casing forms part of ornamental woodwork, the cables are to be readily accessible.

942 Direct-current and alternating-current power, heating, and lighting cables of opposite poles are not to be bunched in the same groove.

943 Precautions are to be taken to ensure that, where cables from different grooves cross one another, they are separated by insulating material.

944 Communication cables connected to systems having a voltage not exceeding 55 volts are not to be fitted in the same groove as cables connected to a system having a higher voltage.

945 Armoured cables and cables having fine wire braiding are not to be fitted in the same groove as cables not similarly protected.

Conduits

946 Conduits, if of steel, and conduit fittings for use therewith, are, with the exception of inspection and draw boxes, to be of heavy gauge and welded or solid drawn.

947 Conduits, if of copper, and clips and saddles for use therewith, may be used, subject to the requirements of 914, provided full particulars are submitted and found satisfactory.

Inspection and Draw Boxes

948 Inspection and draw boxes are to be of metal and shall be in rigid electrical and mechanical connection with the conduits. For steel conduits this connection is to be obtained by screwing into the box or into a device clamping both sides of the wall of the box. For copper conduits this connection is to be obtained by brazing or soldering a suitable ferrule to the conduit, the ferrule being secured to the box by screwing or by clamping to the wall of the box.

Joints During Erection

949 Connections between large vulcanised-rubber-insulated cables are to be made by means of clamped sleeves or tees in joint boxes constructed in accordance with M 379; and those between small cables and between small cables and flexible cables by means of clamped connections contained within suitable receptacles, which in the case of lamp fittings may, if desired, form part of such fittings. Joints in flexible cords are not permissible.

950 Connections between impregnated-paper-insulated cables or between varnished-cambric-insulated cables may, if desired, be made by the same means as for vulcanised-rubber-insulated cables, provided the insulation at their ends is suitably sealed against moisture; or the conductors may be joined by means of copper sleeves, the whole being sweated together. Joints made in this manner are to be lapped with paper or pure cotton tape, impregnated immediately before use, and are to be enclosed in boxes or preferably in lead sleeves or tees wiped on to the cable sheaths, these receptacles being filled with an insulating compound impervious to moisture. Lead sleeves and tees are to be painted with two coats of tough elastic enamel on completion of the joint.

Watertight Glands and Deck Tubes

951 All cables passing through decks or watertight bulkheads are to be provided with deck tubes or watertight glands.

Cables Passing Through Bulkheads, Decks, etc.

952 Unarmoured cables passing through beams, non-watertight bulkheads, decks, etc., are to have the holes through which they pass bushed with lead or other soft non-ferrous metal, or suitable insulating material.

953 In passenger ships trunks for electric cables are to be so constructed as not to afford passage for fire from one between deck or compartment to another.

Circuits of Voltages Exceeding 250 Volts

954 Where a voltage exceeding 250 volts to earth exists or may exist under fault conditions the wiring is to be completely enclosed in strong metal casing or heavy-gauge screwed conduit, or lead-alloy sheathing which is electrically continuous, or, alternatively, the cables and other conductors are to be so constructed, installed, and protected, as to prevent danger so far as is reasonably practicable.

Cables in Lift Shafts

955 In lift shafts and hoist shafts all cables, other than trailing cables, are to be armoured or enclosed in steel or other hard-metal conduits. If conduits are used the control leads and motor leads are to be in separate conduits.

In shafts subject to severe condensation, such as engine room lift shafts, the cables (other than trailing cables) are preferably to be of the lead-alloy-sheathed or the H.R. type, run on the surface of the shaft in such a position as to be clear of wire ropes, trailing cables, etc. Sheet-iron protection covers are to be fitted over cables where liable to sustain damage.

Cables over Expansion Joints

956 Cables are not to be led across expansion joints in the structure unless this is unavoidable. Where cables must cross an expansion joint they shall be arranged with a loop suitably supported having a diameter not less than 12 times that of the largest cable, to ensure the necessary flexibility.

Mineral-Insulated Copper-Sheathed Cables

957 Mineral - insulated copper - sheathed cables may, except as required by 914, be used without further protection of casing, duct or conduit provided they are secured by metal clips having smooth or rounded edges. All clips are to be firmly secured by screws of ample strength and shall, where they are clipped direct to steel or wood grounds, be spaced in accordance with Table XIX. Where cables are spaced away from the bulkhead the spacing of the clips is to be in accordance with that specified for armoured cables in Table XVIII.

958 The ends of mineral - insulated copper - sheathed cables are to be so sealed as to prevent the ingress of moisture, and all moisture is to be expelled from the dielectric before the sealing material is applied. The sealing material, and any material used to insulate the conductors where they emerge from the dielectric, is to have adequate insulating and moisture-proofing properties and be such as to retain these properties throughout the range of temperatures to which the cable-end is to be subjected during normal service.

Cables for Alternating-Current

959 Where single - core cables are used for alternating - current circuits rated in excess of 5 amperes :—

The armouring, if any, is to be of non-magnetic material.

Magnetic material is not to be used between such cables.

Such cables are to be so arranged that the inductive effects of the group are substantially eliminated.

960 Single-core metal sheathed cables are to have their sheaths bonded together and earthed only at approximately the mid-point of the cable run, or alternatively, earthed at both ends, provided that, in the latter instance, the cross-sectional areas of the cables are so increased as to compensate for the increased heating. In the former case such cables are to be carried on insulators to prevent the circulation of currents in the metal sheaths.

The sheaths of multicore cables are to be earthed at each end and long runs are also to be earthed intermediately.

961 Magnetic material is not to be used between single core cables of a group. Where cables pass through steel bulkheads or steel panels, all the conductors of the same set are to pass through a non-ferrous plate or gland so that no magnetic material passes between the cables, and the clearance between the cables and magnetic material is to be not less than three inches.

NOTE.—This paragraph does not apply to cables carrying 10 amperes or less.

Section 10

ACCESSORIES AND LIGHTING FITTINGS

General

1001 Accessories and lighting fittings are to be so designed and constructed that the passages for the insulated conductors are of ample size and are free from rough projections, sharp angles, and abrupt bends. All outlets for cables shall have well-rounded edges or be bushed.

1002 Accessories and lighting fittings are to be so designed, and the insulated conductors so installed, that stress cannot be applied by the conductors to any terminal to which the conductors may be connected.

1003 Accessories and lighting fittings are to be so designed and fixed that dust and moisture cannot readily accumulate on the insulation or live parts.

1004 On weather decks, and wherever exposed to spray or drip accessories are to be of the weather-proof type.

1005 Watertight accessories are to be so constructed as to withstand, without the entry of water, immersion under a 3-feet head of water for a period of 15 minutes before fixing. After erection they are

to be capable of withstanding, without the entry of water, the application of a stream of water ejected without restriction from an ordinary wash-deck hose under a head of 15 feet of water for a period of a quarter of a minute, the outlet of the hose being 6 feet away from the accessory or lighting fitting.

1006 The lanterns of navigation lights are to be of non-ferrous construction and to be weatherproof.

Hygroscopic insulating material is not to be used in such lanterns.

1007 Open-type lighting fittings, whether fixed or portable, are not to be used near readily combustible materials, or in spaces where inflammable or explosive dust or gases are likely to be present or where inflammable goods are stored.

1008 In spaces where explosive or inflammable dust or gases are likely to be present, accessories and lighting fittings are to be of the flame-proof type.

1009 Open-type lighting fittings are not to be furnished with combustible shades unless such shades are kept free from contact with the lamps by suitable guards or supports. Shades and candle tubes composed wholly or partly of nitrated celluloid are not to be used in any situation near a lamp.

1010 Switches and other accessories likely to cause an arc when they are operated are not to be installed in bunkers or other spaces in which inflammable or explosive dust, vapour, or gas, is likely to be present, irrespective of whether such switches or other accessories control lights in such spaces.

1011 The exposed non-conducting metal parts are to be earthed in accordance with the requirements of 1030 and 1031.

Lighting Fittings

1012 Weatherproof lighting fittings are to have metal frames, and are to be so designed that the lamp is completely enclosed within a readily removable glass receptacle.

1013 Portable lighting fittings for the illumination of decks, holds, engine rooms, and similar spaces, are to be of the open type with frames of metal or other suitable material, or, alternatively, they are to be of the weatherproof type. Suitable guards are to be provided to protect the lamp or lamps from mechanical damage. Switches are not to be fixed on portable lighting fittings.

NOTE.—Where alternating-current portable appliances are to be used in machinery spaces, it is recommended that arrangements be made for these to be supplied from a double-wound transformer so designed and connected that the maximum voltage to earth on the appliance and its associated flexible cord or cable does not exceed 25 volts, the appliances being suitably designed to operate at the reduced voltage.

1014 In a portable lighting fitting a metal lampholder which is not in direct metallic contact with the frame of the fitting is to be separated from all metalwork of the fitting by insulating material, of adequate mechanical strength, which will not soften at 302° F. (150° C.), and is to be so shielded by means of similar insulating material that it cannot inadvertently be touched by a person handling the fitting or replacing a lamp. For this purpose a glass bowl of a portable fitting is not to be regarded as an insulating shield for the lampholder.

1015 Every portable lighting fitting is to be provided with a hook or other suitable attachment to enable it to be hung up without damage to the flexible cord.

1016 Flexible cords for portable fittings are to conform to the requirements of M 8. The protective covering, of whatever type employed, is to pass into the fitting or plug and be securely anchored thereto.

1017 Lighting fittings are to be so designed as to provide for adequate dissipation of heat from the lamps, and the insulated wires connected to the fittings are to be suitably protected from the effects of high temperature.

The design is to be such that the temperature of those parts of the fitting which can be readily handled and of the terminals to which insulated cables in which the insulation is not of a heat-resisting type are to be connected does not exceed 170° F. (77° C.) under normal working conditions.

Lampholders

1018 Lampholders are, except as otherwise permitted in 1019, to be of the following standard types*:—

For lamps up to and including 100 watts	Standard bayonet (B.22) or Medium Edison screw (E.27)
For lamps above 100 watts and not exceeding 200 watts ...	Medium Edison screw (E.27)
For lamps above 200 watts ...	Goliath Edison screw (E.40)

1019 Small (E.14, B.15s, B.15d)* and miniature (E.10)* lampholders are not to be used on any system operating at more than 24 volts.

1020 Lampholders are to be constructed wholly of non-ignitable material, and all metal parts are to be of robust proportions. Goliath lampholders are to be provided with effective means for locking the lamp in the holder.

* The designations adopted by the International Electrotechnical Commission for lampholders and lamp-caps are as follows :—

Name of Cap	Designation
Screw Caps :—	
Goliath	E.40
Medium	E.27
Small	E.14
Miniature...	E.10
Bayonet :—	
Normal	B.22
Small single contact	B.15s
Small double contact... ...	B.15d

Switches

1021 Switches are to be constructed wholly of durable self-extinguishing, non-hygroscopic materials.

Ceiling Roses

1022 Ceiling roses are to be constructed of non-ignitable, non-conducting, non-hygroscopic material.

Socket-Outlets and Plugs

1023 The live parts of socket-outlets and plugs are to be so proportioned that their average temperature does not exceed by more than 54° F. (30° C.) that of the surrounding air when the normal working current is flowing through them continuously.

1024 Socket-outlets and plugs are to be so constructed that they cannot be readily short-circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket.

1025 The clearances of socket-outlets and plugs not interlocked with switches are to be such that an arc cannot be maintained if the plug be withdrawn from the socket while a current 50 per cent greater than that for which they are rated is flowing under a voltage 50 per cent in excess of the voltage of supply.

1026 All socket-outlets having a current rating of 15 amperes or more are to be provided with a switch.

1027 On weatherdecks, in stokeholds and engine rooms, and wherever exposed to drip or spray, socket-outlets and plugs are to be of the weatherproof type.

1028 Weatherproof socket-outlets and plugs are to be of specially robust construction and be provided with efficient means to maintain the socket-outlet weatherproof when the plug is removed therefrom. Where a loose cover is employed for this purpose, it is to be anchored to a socket-outlet by means of a chain. When the plug is inserted in its socket-outlet the combined fitting and interlocking switch, if any, is also to be weatherproof.

1029 All live parts the voltage of which exceeds 150 volts alternating-current to earth or 250 volts direct-current to earth are to be suitably enclosed.

Earthing of Lighting Fittings

1030 The exposed metal parts of all lighting fittings other than portable lighting fittings are to be earthed. The earthing may be effected by the securing screws where such fittings are secured direct to the steel structure of the ship or to metal plates in effective metallic contact with such structures. Where fittings having exposed metal parts are secured to wood or other non-metallic materials, the earthing is to be effected by a conductor of adequate cross-sectional area and mechanical strength in permanent and substantial connection with the exposed metal parts and the ship's structure.

1031 Every portable lighting fitting with exposed metal parts which might otherwise become alive is to have such parts earthed through an earth-continuity conductor which is to be in effective electrical connection with the exposed metal parts and with the earthing pin of the plug connection.

Note.—It is recognised that it is difficult to ensure that earth connections remain effective, and it is therefore recommended that, wherever practicable, fittings which are not to be permanently secured to the steel structure of the ship (e.g., portable fittings and fittings secured to wooden structures) should be of the all-insulated type.

Section 11

LAMPS

Arc Lamps other than Searchlight Lamps

1101 Arc lamps are to have the whole of their live parts insulated from the frame or case.

1102 Every arc lamp is to be provided with a globe or lantern arranged to intercept falling particles

of carbon, and with wire netting of not greater than 3-inch mesh so arranged as to prevent large pieces of broken glass falling therefrom.

1103 Arc lamps are to be so supported that they cannot swing into contact with any metallic object.

1104 Every arc lamp circuit is to be controlled by a fuse and switch on each insulated pole. Where more than one pole is insulated the switches are to be linked.

1105 Arc lamps are not to be installed or used in positions where inflammable goods are stored, or where inflammable or explosive dust, vapour, or gas, is likely to be present under normal conditions.

Searchlight Lamps

1106 Searchlight lamps are to have the whole of their live parts insulated from the frame or case.

1107 All parts of a searchlight lamp which have to be handled for its operation or adjustment while in use are to be insulated from the circuit with strong, non-ignitable material, of substantial proportions, and be so disposed that there is no risk of shock to the operator.

1108 Where a circuit supplies a searchlight of arc lamp type it is to be controlled by a fuse and switch on each insulated pole. Where more than one pole is insulated the switches are to be linked. If a series resistance is used with the searchlight lamp, the controlling switch is to be in the supply leads to the resistance and not between the resistance and the searchlight lamp.

1109 The frame of every searchlight connected to a supply system having a voltage of 50 volts or above is to be provided with a suitable terminal to which the earth continuity conductor is to be connected.

Lamps for Navigation Lights

1110 All lamps for navigation lights are to be of the Ministry of Transport standard pattern and are to have a rating of not less than 40 watts.

Electric Discharge Lamps

1111 Where electric discharge lamps or luminous discharge tubes are used, lighting by one or more incandescent filament lamps is to be provided as necessary to ensure safety in the event of the extinction of the discharge lamps.

1112 Electric discharge lamps are to be so arranged as to operate satisfactorily with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to 22½ degrees from the vertical.

Tubular Fluorescent Lamps

1113 Where tubular fluorescent lamps designated MCF/U with preheated cathodes are used, the requirements detailed in 1114 to 1117 are to be observed.

1114 All fittings, chokes, capacitors and other auxiliaries are to be of a type suitable for marine service. For all ocean-going ships and ships operating in tropical waters the fittings, chokes, capacitors, etc., are to be capable of operating under tropical conditions. They are not to be mounted on surfaces which are liable to be subjected to high temperatures.

1115 Every capacitor having a rated capacitance of 0·5 microfarad or over is to be provided with a means for its prompt discharge (e.g., a permanently connected parallel resistance) on disconnection of the supply.

1116 Linked switches arranged to disconnect all poles of the supply are to be used for all distribution and control switches feeding such lamp circuits.

1117 In ships where the distribution system is mainly direct-current the section boards and distribution fuse-boards for alternating-current supplies feeding such lamp circuits are to be clearly and permanently marked :—

WARNING
.....VOLTS A.C.

Section 12

ELECTRIC MOTORS

Rating of Motors

1201 Motors are to conform to Appendix 3.

1202 The temperature rises of motors (except pipe-ventilated or water-cooled machines and motors for machine tools) situated in machinery spaces (including boiler rooms), steering gear compartments and refrigerated cargo spaces and on weather decks of all ocean-going ships and ships operating in tropical waters, when measured in accordance with Appendix 3, are not to exceed the limits shown in Table XXIV.

For machine tool motors and for motors in such ships located elsewhere than in the machinery spaces (including boiler rooms), steering gear compartments and refrigerated cargo spaces and on weather decks where the normal temperature of the cooling air will not exceed 104° F. (40° C.) the temperature rises are not to exceed those shown in Table XXV.

For pipe-ventilated motors taking cooling air from outside the machinery space or boiler room where the normal temperature of the cooling air under service conditions will not exceed 104° F. (40° C.) the temperature rises are not to exceed the limits shown in Table XXV.

For water-cooled motors with coolers using water with an inlet temperature not exceeding 85° F. (29·5° C.), the temperature rises are to be measured relative to the inlet temperature of the water and the permissible temperature rises shown in Table XXV may be increased by 18° F. (10° C.).

1203 The temperature rises of all motors in ships such as coasters, ferries and harbour craft intended solely for use in northern and southern waters outside the tropical belt are not to exceed the limits shown in Table XXV.

NOTE.—For alternating-current installations, in order that the highest practicable operating power factor may be obtained, the installation of over-sized motors should be avoided, and motors should be selected to have ratings as close as practicable to the actual load requirements.

1204 Flameproof motors are to conform to Appendix 6.

Excessive Ambient Temperature

1205 Where the temperature of the cooling air exceeds 113° F. (45° C.) in the case of motors where Table XXIV applies and 104° F. (40° C.) where Table XXV applies or where water cooling is used and its temperature exceeds 85° F. (29·5° C.) the permissible temperature rise of the motors is to be reduced by an amount equal to the excess temperature.

Testing

1206 Each motor intended to be used on essential services in ocean-going ships (except trawlers) and ships operating in tropical waters is to be tested at the maker's works, and a certificate giving the results is to be submitted for approval.

The tests are to include :—

A temperature test at that rating which produces the greatest temperature rise. In cases where this cannot be predetermined, the machine is to be tested separately under each of its ratings.

Speed-load characteristics.

Speed range if variable speed.

Insulation resistance.

High voltage test.

Machines of 100 b.h.p. and over, intended to be used on essential services, are to be inspected by the Surveyors during manufacture and testing.

NOTE.—A list of motors considered as typical of essential services is given in M 2403.

1207 Where the air circulating fans for refrigerated chambers are electrically driven, plans showing the construction of the motors are to be submitted for consideration and the motors are to be inspected by the Surveyors during manufacture. Type tests on the first motor of each size and type are to be carried out in the presence of the Surveyor in accordance with Appendix 3 and abbreviated tests are to be carried out by the maker and certificates giving the results are to be submitted for approval.

Construction of Motors

1208 Only Class A or Class B insulating materials, in accordance with Appendix 2, are to be used in the construction of motors.

1209 All motor windings are to be treated to resist moisture, sea air, and oil vapour.

1210 In motors for essential services, the following additional requirement is to be complied with :—

All motor windings are to be insulated from their frames and/or cores with mica or micanite, and in bar-wound armatures the insulation between conductors or between upper and lower layers or equivalent portions, between which there is a periodic full rated voltage, is to be of micanite or other similar non-hygroscopic non-inflammable material.

1211 All working parts of motors are to be readily accessible, and all live parts in excess of 250 volts direct current to earth or 150 volts alternating current to earth are to be suitably guarded or enclosed (*see* M 413).

1212 Where welding is applied to shafts of motors engaged on essential services for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

Brushes

1213 Motor brushes for use on commutators or slip-rings are to be of carbon, graphite, or metal-graphite, and are to be provided with flexible copper connections.

1214 Commutator brushes are to be staggered longitudinally in such a manner that in multipolar motors every part of the commutator working surface is swept by the brushes, to prevent the formation of ridges. The staggering is to be so arranged that in multipolar direct-current motors a positive brush is always in line with a negative brush on an adjacent brush arm.

Terminals

1215 Suitable terminals, clearly marked, are to be provided in an accessible position, convenient for wiring, and where cable connections are used they are to be provided with cable sweating sockets. The terminals are to be effectually secured and are to be so spaced and/or shielded that they cannot be accidently earthed, short-circuited, or touched.

Mechanical Balance

1216 Every motor is to be so constructed, erected, and supported, that when running at any and every working speed all revolving parts are well balanced, and the motor is not to give rise to any appreciable vibration on the test bed in service.

Lubrication

1217 Motors are to be efficiently and continuously lubricated automatically at all running speeds and all normal working oil temperatures when continuously inclined from the normal at any angle up to 15 degrees and when the ship is rolling up to $22\frac{1}{2}$ degrees from the vertical without the spilling of oil, with the exception that the longitudinal angle may be limited to 10 degrees for motors placed with their axes of rotation in a fore-and-aft direction. Where ring lubrication is employed, the rings are to be so constrained that they cannot leave the shaft. Oil flingers or other suitable means are to be provided to prevent the lubricant creeping along the shaft or otherwise gaining access to the insulation of the machine or any live part thereof. Every oil-lubricated bearing is to be provided with a suitable overflow which, while permitting efficient lubrication when the machine is running, is to prevent the bearing from containing an excess of oil.

1218 Every self-lubricated sleeve bearing is to be fitted with an inspection lid and means for the visual indication of the oil level.

1219 Where forced lubrication is employed, an alternative means of lubrication such as oil rings or an oil reservoir is to be provided if no warning device is fitted, or a period exceeding 30 seconds elapses before the machine comes to rest after the interruption of power.

Earthing

1220 The bedplate (if any) and frame of every motor is to be effectually earthed.

Shaft Currents

1221 Means are to be taken to prevent the formation of circulating currents which might flow between the shafts and the bearings.

Position in Ship

1222 Motors are, wherever possible, to be placed in well-ventilated compartments in which inflammable gases cannot accumulate, and in all cases are to be fixed clear of all inflammable material. Where these conditions cannot be complied with, motors fitted in such compartments are to be of the flame-proof type or forced-draught type with supply and exhaust pipes or ducts taken outside the compartment.

1223 Motors are, as far as possible, to be placed in positions in which they are not exposed to risk of mechanical injury or to damage from water, steam, or oil. Motors necessarily exposed to such conditions are to be of one of the following types:—

Totally-enclosed, including totally-enclosed fan-cooled.

Pipe-ventilated.

Drip-proof.

Watertight.

Immersible.

1224 Pipe-ventilated motors are to be supplied with air as cool as possible, and the air intakes are to be guarded against the admission of dirt and/or moisture.

1225 Motors essential to the safety of the ship in the event of damage (e.g., emergency bilge-pump motors) are to be so installed as to be capable of running for a reasonable period after the compartment in which they are situated has been flooded.

Axes of Rotation

1226 Motors, other than those of the vertical spindle type, are, wherever possible, to be placed with their axes of rotation in a fore-and-aft direction. The end play is to be reduced to a minimum, and adequate provision is to be made for taking the end thrust due to the motion of the ship.

Unprotected Woodwork, etc.

1227 No unprotected woodwork or unprotected, readily combustible material is to be within a distance of 12 inches measured horizontally from, or within 4 feet measured vertically above, any motor, unless the latter is enclosed.

Fans for Refrigerated Cargo Chambers

1228 In cargo refrigerated installations intended for reducing the temperature of fruit cargo, fan motors fitted in the air stream are to be totally enclosed where they are fitted between two sections of a cooler or where the air from the cooler passes over the motor.

Heat Exchangers

1229 If water-cooled heat exchangers are used they are to be so arranged as to prevent leakage or condensation from the cooler tubes from entering the machine.

Section 13

MACHINE CONTROL GEAR

General Construction

1301 Field rheostats, speed regulators, motor starters, and motor controllers, are to be constructed wholly of durable, non-ignitable, non-hygroscopic materials, and unless otherwise guarded from approach, and where used for switchboards, are to be enclosed in non-ignitable cases.

1302 Machine control gear is to be unaffected by vibration or shock, and is to operate satisfactorily under all conditions with the ship inclined from the normal at any angle up to 15 degrees transversely and 10 degrees longitudinally, and with rolling up to $22\frac{1}{2}$ degrees from the vertical.

1303 The contact-making faces of machine control gear are to be sufficiently numerous to prevent destructive arcing, and the contacts and fingers of motor controllers and contactors are to be capable of withstanding at least 5,000 operations under full-load conditions without undue wear. At full-load current and full voltage, the interruption of the arcs is to be effected without the projection of molten metal and without destructive arcing. The wearing parts are to be easy to replace without completely dismantling the apparatus.

1304 Handles and their attachments of machine control gear are to be mechanically strong, and are to be so designed and arranged that the hand of the operator, when using the device, cannot touch live metal, or be injured through an arc arising from the device.

1305 Operating handles of machine control gear are not, under working conditions, to have a temperature rise of more than 27° F. (15° C.) above the ambient air temperature.

1306 The cases of machine control gear are to be effectually earthed.

1307 The clearances and creepage distances are to be suitable to the nature of the insulation provided, the provision made for arc quenching and the operating characteristics of the apparatus. The following figures are to be regarded as minimum values applying to non-arcing parts in favourable circumstances in air and in oil, to earth or between poles or phases.

	Up to 250 V.		Above 250 V. and up to 440 V.		Above 440 V. and up to 650 V.	
	Clearance	Creepage	Clearance	Creepage	Clearance	Creepage
	inches	inches	inches	inches	inches	inches
Up to 10 amperes	$\frac{3}{16}$	$\frac{3}{8}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{1}{2}$
Over 10, up to 75 amperes	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$
Over 75 amperes	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{5}{8}$

The clearance between arcing contacts and the case is to be such that operation within the rating of the apparatus can be carried out satisfactorily.

1308 Where conduit is used for the external connections to machine control gear, the conduit is to be securely attached to the case and is to be so arranged as to enclose the cable completely at the point of entry into the case. Where lead-alloy-sheathed and/or armoured cable is used, provision is to be made to ensure that the metallic sheathing of the cable is so attached to the case of the apparatus as to ensure adequate electrical continuity.

Temperature Limits

1309 The temperature limits specified in 1311 and 1312 are not to be exceeded. Where the ambient air temperature exceeds 104° F. (40° C.), the specified temperature rise is to be correspondingly reduced so that the specified total temperature is not exceeded.

1310 Continuously rated contacts and conductors are to be capable of sustaining the rated full-load current continuously and a 25 per cent overload for two hours after having reached a steady temperature corresponding to full-load, without injury to themselves and without causing damage to any adjacent parts.

1311 The temperature limits of release, blow-out, contactor-operating, and relay coils which are left in circuit continuously at rated voltage and/or rated current, are not to exceed the values given in Table XXIII, temperature measurements being made by thermometer or by thermo-couple on the surface.

1312 The total temperature of metallic resistors is not to exceed 464° F. (240° C.) at any point [360° F. (200° C.) temperature rise] as measured by a thermometer placed in contact with the resistance material. The total temperature of the air issuing from a ventilated resistor is not to exceed 284° F. (140° C.), that is a temperature rise of 180° F. (100° C.), measured at a point 1 inch from the case. Where the temperature of any part of the case of a totally enclosed resistor is likely to exceed 170° F. (76·6° C.), the apparatus is to be so located or guarded as to prevent it from being inadvertently touched.

Resistors

1313 Internal connections of resistors are not to have soldered joints unless such joints are primarily secured mechanically. Bare connections of resistors are to be sufficiently rigid, or are to be supported to prevent movement, or continuously insulated with porcelain beads, care being taken to prevent short-circuiting at crossings in the event of breakage or displacement of beads, or insulated with fire-proof non-hygroscopic material suitably supported to prevent contact with earthed metal or wires of opposite polarity.

1314 Where resistors are not self-supporting or rigidly fixed, they are to be supported throughout their length by non-ignitable, non-hygroscopic insulating material.

1315 Resistance elements, other than those of shunt field regulators, are to be readily replaceable.

Range of Operation

1316 Shunt operated contactors, releases and relays are to be capable of functioning satisfactorily even when the line voltage falls to 80 per cent for direct current and 85 per cent for alternating current at any permissible temperature within the working range.

Terminals

1317 Suitable terminals with soldering sockets or mechanical clamps are to be provided for the attachment of external leads, and are to be so situated that such leads are not exposed at any point to a high temperature.

1318 Soldered sockets are not to be used on resistors unless a separate terminal board, not subject to high temperature, is provided.

Position in Ship

1319 Machine control gear is, wherever practicable, to be placed in well-ventilated positions, free from the likelihood of an accumulation of inflammable vapour or gas. When such conditions cannot be complied with, such apparatus is to be flame-proof.

1320 Machine control gear is, wherever practicable, to be placed in positions in which it is not exposed to risk of mechanical injury or to damage from water, steam, or oil. Where necessarily exposed to such conditions it is to be totally enclosed. Glazed windows are to be as small as possible, consistent with their purpose, and are to be suitably protected.

1321 Resistors are to be placed in well-ventilated compartments, free from the likelihood of an accumulation of inflammable gases, and in such positions as to be clear of all inflammable material. No unprotected woodwork or unprotected, readily combustible

material is to be within a distance of 6 inches measured horizontally from, or within 24 inches measured vertically above, the frames or cases of resistors.

Control of Motors

1322 Every electric motor is to be provided with efficient means for starting and stopping, so placed as to be easily operated by the person controlling the motor; and, except for selected motors the continuous availability of which is essential for the safety of the ship, every electric motor having a rating exceeding one-half horse-power is to be provided with control apparatus complying with the following sub-paragraphs:—

(*a*) Means to prevent the motor re-starting after the under-voltage release has operated where the unexpected re-starting of the motor might cause injury to the operator.

NOTE.—It is recognised that certain applications require the automatic starting of a motor at irregular intervals in response to control devices which are governed, for example, by thermostatic, pneumatic or hydraulic devices. In such applications it is intended that the motor should start automatically on the restoration of supply.

(*b*) A starter or switch for limiting the starting and accelerating current to the extent, if any, necessitated by the capacity of the available generating plant or of the cable network.

(*c*) Efficient means of isolation suitably placed and so connected that all voltage may thereby be cut off from the motor and all apparatus, including any automatic circuit-breaker, used in connection therewith.

(*d*) Where the primary means of isolation is remote from a motor, an additional means of isolation is to be installed adjacent to the motor starter, or, alternatively, provision is to be made for locking the primary means of isolation in the off position.

NOTE.—The "primary means of isolation" is that provided at the switchboard section-board or distribution fuse-board.

1323 Where a single master-starter system (i.e., a starter used for controlling a number of motors successively) is used, the apparatus is to provide under-voltage and over-current protection, and, for each motor, means of isolation not less effective than that required for systems employing a separate starter for each motor. Where the starter is of the automatic type, suitable alternative means is to be provided for manual operation. Where the starter is employed for the starting of motors for essential services, the starting portion is to be duplicated and means are to be provided for transfer in the event of failure of one of the starters.

Protection of Motor Circuits

1324 Every electric motor having a rating exceeding one-half brake-horse-power except selected motors, e.g., steering gear, the continuous availability of which is essential for the safety of the ship is to be provided with a means to disconnect the supply automatically in the event of the current becoming excessive owing to mechanical overloading of the motor. In the case of polyphase motors, this shall consist of a linked circuit-breaker or a linked contactor with protective devices so arranged that an over-current in any one phase will disconnect all insulated poles.

NOTE.—To comply with this requirement it is generally necessary to provide local protection additional to that given by means of fuses or circuit-breakers at the source of supply.

Full-Load Currents of Motors

1325 For motor control gear, the maximum current of an electric motor is to be deemed to be the full-load rated current of the motor, and, unless the actual current be known, is to be taken to correspond to the values given in Table XXI for the types referred to therein. For motor outputs between those shown in the Table, the full-load current is to be taken to be directly proportional to the output and is to be calculated from the next lower output in the Table.

Testing

1326 Control gear and resistances are to be tested by the makers with a high voltage applied between the earthed frame and all circuits between live parts forming positions of independent circuits. The test voltage is to be 1,000 volts plus twice the rated voltage, with a minimum of 2,000 volts alternating of any frequency between 25 and 100, maintained for one minute. Instruments forming part of the apparatus are to be included in this test unless the scale-length is 3½ inches or less, in which case they are to be isolated and tested separately at 1,000 volts.

Shunt Field Circuits

1327 Control gear, including isolating and reversing switches, is to be so arranged that shunt field circuits are not disconnected without an adequate discharge path being provided.

Section 14

HEATING AND COOKING APPLIANCES

General Construction

1401 All electric heating and cooking appliances are to be so constructed and mounted that their supports and those parts which have necessarily to be handled in use cannot become heated to a temperature exceeding 130° F. (54° C.). The heating elements are to be of materials durable at the highest temperature which they attain, and are to be so arranged that they can be readily replaced.

1402 The electrical connections between the heating elements are to be effected either by joining parts of the elements themselves or by such construction that the connecting conductor will not deteriorate at the maximum temperature to which it may be subjected. The junction between the elements and switches or external connecting leads is to be effected without solder by suitable connections, which are to be so placed that the temperature of any part of the switches or terminals to which insulated cables may be connected cannot exceed 170° F. (76·6° C.).

1403 All connections between heating elements and between heating elements and terminals to which insulated cables may be connected are, unless self-supporting or rigidly fixed in position, to be continuously insulated with suitable non-inflammable material.

1404 All live parts, whether heating elements or terminals, are to be carried on non-hygroscopic non-inflammable insulating material.

1405 The heating elements of heating appliances are to be suitably guarded. The guards are to be of robust construction and so fitted that they cannot be brought into contact with them.

1406 All live parts of cooking appliances are to be so protected that the cooking utensils cannot be brought into contact with them.

Provision for Earthing

1407 All heating and cooking appliances, whether portable or fixed, are to be provided with suitable terminals for earthing the metal framework, and such terminals are to be effectively connected to earth.

Control

1408 Every heating and cooking appliance, whether portable or fixed, is to be controlled locally by a fixed switch, and where a socket-outlet is provided it is to be connected between the switch and the appliance.

Portable Appliances

1409 All portable heating and cooking appliances are to be of such shape or so weighted that they cannot easily be overturned, and suitable stowage positions are to be provided for them.

Protection of Inflammable Materials

1410 All inflammable materials in the vicinity of heating and cooking appliances are to be protected by suitable fire-resisting materials. Every heating appliance is to be so mounted that there will be at least one inch of air space between the appliance and the deck or bulkhead. Heaters are to be so designed and protected that clothing or other inflammable material cannot be placed over them in such a manner as to cause risk of fire.

Space Heaters

1411 Heaters are to be fixed in position and are to be such as to heat the surrounding air by convection except that heaters of the radiation type may, if desired, be used provided they are so constructed and installed that the element is not so exposed that clothing, curtains, bedding or other similar material can be scorched or set on fire by heat from the element and full details are submitted in advance for consideration.

1412 Heaters are to be durable and all parts are to be of robust construction. The protecting guards are to be strong enough to resist being forced against any current-carrying part. The openings are to be of small size to prevent the heating elements from being short-circuited or injured by accident.

1413 Internal connections are to be either bare wires sufficiently rigid to be self-supporting or insulated with non-ignitable non-hygroscopic material suitably supported to prevent contact with earthed metal or wires of opposite polarity. Where porcelain beads are used care is to be taken to prevent short-circuiting at crossings or earthing in the event of breakage or displacement of beads.

1414 All screws and nuts are to be effectually locked.

1415 All heaters are to be tested at the maker's works and are to withstand 1,500 volts alternating current at any frequency between 25 and 100 cycles per second applied for one minute between all current carrying parts and the metal frame (if any) and/or fixing lugs.

Explosion Risks

1416 In situations in which an inflammable vapour or gas is likely to accumulate, heating appliances capable of igniting such vapour or gas are not to be installed.

Section 15

SPECIAL REQUIREMENTS FOR PETROLEUM TANKERS AND FOR SHIPS CARRYING OIL IN BULK HAVING A FLASH POINT LESS THAN 150° F. (65·5° C.).

General

1501 Where flame-proof construction is specified in this Section, the apparatus is to comply with the requirements of flame-proof gear as specified in Appendix 6. Further, where flame-proof apparatus is required to be used, and apparatus is obtainable which is covered by a certificate issued by a competent independent Testing Authority, such apparatus only is to be used.

Nature of Supply

1502 For direct-current systems the voltage of supply is not to exceed :—

For power, heating and cooking ...	230 volts.
For lighting, cabin fans and socket outlets in accommodation spaces	115 volts.

1503 For alternating-current systems the voltage of supply is not to exceed :—

For power, single phase	250 volts.
For power, three phase...	440 volts.
For heating	250 volts.
For galley heating and cooking equipment permanently connected to fixed wiring, three phase	440 volts.
For calorifiers of 7·5 kW and over and for lubricating and fuel oil heaters permanently connected to fixed wiring, three phase	440 volts.
For lighting, cabin fans and socket outlets in accommodation spaces	115 volts.

1504 Lighting circuits, cabin-fan circuits, and heating circuits are not to have any electrical connection with a circuit (or source of supply) of higher voltage than those specified above.

Generating Plant

1505 Generating plant is to be fitted in the main engine room, or, alternatively, in a well ventilated machinery space separated from the cargo tanks by a cofferdam or equivalent safety space.

1506 Two or more generating sets are to be provided of such combined output that, in the event of one set being out of service, the remaining generating plant is capable of carrying the normal working load, except that in ships of less than 500 tons gross measurement where the supply is not employed for essential power services one set only need be fitted, provided that the following spares are carried :—

For direct-current installations a spare generator armature and set of field coils (including commutating-pole coils, where commutating poles are fitted).

For alternating-current installations, a spare armature (rotating or stationary) and two field coils for both the alternating-current generator and the exciter.

The requirements of this paragraph also apply to motor-generators where used for the supply to lighting circuits.

Switchboards

1507 The main switchboard is to be fitted in the same compartment as the generating plant.

1508 All switchboards, section boards, distribution fuse-boards, and joint boxes, are to be fitted well clear of boilers, steam or oil pipes, settling tanks, and Diesel-engine exhaust pipes or manifolds.

1509 Every outgoing circuit from the main switchboard and section boards is to be provided with a multi-pole (linked) circuit-breaker or, alternatively, a multi-pole (linked) switch arranged to interrupt the circuit on all poles simultaneously, with fuses of the type required in 1529 on each pole.

1510 Every earth-indicating device, other than one depending solely on lamps, is to be so designed that the flow of current to earth cannot exceed 30 milliamperes, and the inductance of the path to earth in the indicating circuit is not to exceed

60 millihenries. Where an earth-indicating system using two lamps is adopted, such lamps are to be of the metal-filament type, each not exceeding 15 watts. The system employing a single lamp is not to be used.

NOTE.—To facilitate comparison of the brilliance of earth indicating lamps they should be of the same colour and size and should be placed not more than 6 inches apart.

Distribution

1511 No current-carrying part of the system is to be earthed, except as provided for in 1510, or through capacitors as may be required for the abatement of radio-interference or the secondary circuits of current- and potential- transformers.

1512 All cables, other than mineral-insulated copper-sheathed cables, flexible cables and cables in accommodation and machinery spaces (*see* 1513) are to have the protective sheathing specified below, according to the conditions under which they are installed.

Where run exposed, without additional protection from mechanical damage :—

Lead-alloy-sheathed and armoured, with or without braiding over the armour.

Where protected from mechanical damage or run in pipes :—

Lead-alloy-sheathed and either armoured or metal braided

1513 Cables (other than flexible cables) in accommodation and machinery spaces are to be lead-alloy-sheathed (with or without braiding, armour or armour and braiding) or mineral-insulated copper-sheathed.

1514 The cables referred to in 1518 are to be mineral-insulated copper-sheathed or insulated with varnished cambric or with rubber of highest quality and specially suitable for withstanding extremes of temperature.

1515 Every flexible cable is to be provided with an earth continuity conductor in addition to the current-carrying conductors and, except for flexible cords in cabins and accommodation, the nominal cross-sectional area of every conductor in the cable is to be not less than 0·003 square inch. The earth continuity conductor in the flexible cable is to be effectively connected to the earth pin of the plug at one end and to the metal, if any, of the portable appliance at the other end. Every flexible cable is also to be provided with means for relieving the conductors of mechanical stress, and is to be so installed that such means are effective. Flexible cords in cabins and accommodation are to comply with the requirements of M 805 to M 807.

1516 Every flexible cable is to have the cores so laid up and arranged as to provide the maximum degree of flexibility and freedom from internal damage due to twisting and kinking. For flexible cables having a nominal cross-sectional area greater than 0·007 square inch, an external close-fitting sheath of tough rubber reinforced with embedded canvas is to be fitted, and it is to be of sufficient thickness and strength to protect the cores from external damage by heavy compression and abrasion.

Installation of Cables

1517 Cables are to be so installed that they are not subjected to tension or chafing due to the working of the ship's structure.

1518 Cables installed on deck or under fore-and-aft gangways are to be run either in substantial channels of steel bar or plate, or, alternatively, in galvanised steel pipes fitted with bolted flanged joints or screwed unions. The thickness of the steel pipes is to be not less than that stated in the following schedule :—

Nominal Bore of Pipe inches	Minimum SWG	Thickness of Pipe inch
$\frac{3}{4}$	10	0·128
1	9	0·144
$1\frac{1}{4}$	8	0·160
$1\frac{1}{2}$	7	0·176
2	7	0·176
$2\frac{1}{2}$ to 6	6	0·192

1519 Where channels or plating are employed the ends are not to be rigidly attached to bulkheads at the poop, midships house, and forecastle, and suitable expansion bends or bights are to be provided in the cables at these points.

1520 Where pipes are employed the total cross-sectional area of the cables contained within a single pipe is not to be more than 30 per cent of the internal cross-sectional area of the pipe. Substantial stuffing boxes with adjustable packed glands are to be provided at intervals in the run of pipes to allow for expansion and contraction, and the working of the ship. In particular, stuffing boxes are to be fitted at each bulkhead through which the pipes pass. The run of the

pipes is to be as direct as possible to facilitate the drawing in of cables, and all parts of the pipe system are to be effectively drained and ventilated, and earthed in accordance with M 934.

1521 All cables, except mineral insulated copper-sheathed cables, and all pipes containing cables, running fore and aft are, throughout their length, to be kept at such a distance from steam and exhaust pipes as to be substantially free from any heating effect from such pipes. At the bulkheads this distance is to be not less than 18 inches from the flanges of steam pipes of more than 3 inch diameter, and not less than 12 inches from the flanges of steam pipes of 3 inch diameter or less.

1522 The total number of cables installed on the fore-and-aft gangway is to be reduced to a minimum.

Voltage Drop

1523 In computing the sizes of main cables running forward from the engine room, special care is to be taken to avoid excessive voltage drop (*see* M 617), in view of the length of such cables on this class of ship.

Fittings and Accessories

1524 The enclosing cases of all section boards and distribution fuse-boards, are to be wholly of metal and, except in accommodation spaces, are to be weatherproof. Except in accommodation spaces, enclosing cases of lighting fittings and accessories are to be wholly of metal and are to be weatherproof or flameproof as required under 1528 and 1530. All metal cases are to be effectively earthed.

1525 All switches in distribution circuits are to be of the multi-pole linked type.

1526 Switches controlling the lighting fittings referred to in 1530 (*a*) and 1535 are to be fitted in safe positions, and are not to be immediately adjacent to the lighting points.

1527 Every socket outlet for use with flexible cables is to be provided with means for connecting to earth an earth-continuity conductor in the flexible cable attached to the portable appliance.

1528 Switches and socket outlets other than those of the flameproof type are not to be fitted within 10 feet of any oil tank outlet or vapour outlet.

1529 Every fuse-element fitted on a switchboard, section board and distribution fuse-board is to be entirely enclosed in a non-ignitable non-hygroscopic insulating cartridge filled with refractory material. They are to comply with the requirements of M 362 to M 369.

Lamps and Appliances

1530 No lighting fitting, electrical appliance, or wiring of any kind, is to be installed in any oil tank, cargo pump room (except as permitted in 1535 and 1536), cofferdam, or any other space immediately adjacent to and below the top of the oil tanks. Every lighting fitting is to have as a minimum the following enclosure corresponding to its position or use in the ship :—

(*a*) In between-deck spaces immediately above any oil tank—Flame-proof.

(*b*) On open decks within a distance of 10 feet from any cargo oil tank outlet or vapour outlet—Flame-proof.

(*c*) Portable lamps fed by flexible cables—Weatherproof, and provided with strong metal guards.

(*d*) In engine rooms (except floodlights), store rooms, dry cargo holds, and similar safe spaces, also about the open decks, other than in the positions defined above—Weatherproof.

Floodlights in engine rooms may be of the open type provided they are drip-proof and the lamp sockets are of the Edison screw type.

(*e*) Navigation and signal lights—Weatherproof.

1531 Luminous discharge tubes and electric discharge lamps, other than tubular fluorescent lamps (Type MCF/U), are not to be used.

1532 Searchlights, other than those required to be fitted in compliance with the Suez Canal requirements for navigational purposes, are not to be of the carbon-arc type. The frames and all non-conducting metal parts are to be effectively earthed.

Portable Appliances

1533 The metal frame of every portable electric lamp, drill, and other appliance, fed through a flexible cable is to be provided with suitable means for permanent connection to the earth continuity conductor of the flexible cable, and is to be earthed.

Heating and Cooking Appliances

1534 Electrical cooking appliances (except where they are installed in the ship's galley aft of the oil tanks) and all electrical heaters are to be of the black-heat type the temperature of which does not exceed 575° F. (302° C.) under normal working conditions, and are to be securely fixed in position and permanently connected to fixed wiring and metal frames are to be earthed.

Cargo Pump Rooms

1535 Cargo pump rooms are to be adequately lighted by lamps enclosed in flame-proof lighting fittings permanently connected to fixed wiring and fitted wholly outside the space, always provided that pump rooms immediately adjacent to an engine room or similar safe space may be lighted through substantial gas-tight permanently fixed glazed ports, fitted in the bulkhead, and, where the lighting fitting is not immediately in contact with the bulkhead, the fitting used in such safe space need not be of flame-proof type.

1536 Alternatively cargo pump rooms may be lit by certified flame-proof fittings located in the compartment and complying with the following :—

The lamps are to be arranged on at least two independent circuits controlled by fuses and switches located in a safe space outside the compartment. The lamps and corresponding switches and fuses are to be suitably labelled for identification purposes.

Well-glasses and the like are to be suitably protected from damage, and are to be secured by screws or nuts requiring a special key for their removal.

The cables are to be run in heavy gauge steel conduit with flame-proof accessories or to be spiral wire armoured, kept clear of the bulkheads and suitably protected, where necessary, from mechanical damage.

Portable Lamps

1537 Portable lamps, other than self-contained battery-fed lamps of a type approved by a competent independent Testing Authority for use in explosive petroleum atmospheres, and gas detecting lamps similarly approved, are not to be used in any oil tank, pump room, cofferdam, or any other space immediately adjacent to and below the top of the oil tanks, unless the atmosphere therein has been tested and certified to be free from such explosive mixtures.

1538 Enamelled iron or similar permanent notices of ample size are to be secured in two or more conspicuous positions prohibiting the use of lamps and other electrical appliances fed by flexible cables in the oil tanks, cofferdams, or pump rooms, unless they have been certified to be free from explosive mixtures.

1539 Portable lamps and other portable electrical appliances are not to be used unless previously inspected to see that all parts are in position and that the earthing and other connections are in good order at the plug and the appliance.

Motors, etc.

1540 Motors and their starting or control gear are to be fitted only in the undermentioned positions, and are to have as a minimum the enclosure corresponding to each position :—

Machinery and steering gear spaces—Drip-proof type.

Open deck, within 10 feet from an oil tank outlet or vapour outlet—Flame-proof type; elsewhere on open deck—Watertight type.

Radio and gyro-compass rooms where not liable to an accumulation of inflammable vapour—Protected type.

Living accommodation (small cabin fans only)—Protected type.

Electrical Apparatus in 'Tween Deck Spaces

1541 Electrical apparatus other than the fittings permitted by 1530 (*a*) may be fitted in 'tween deck spaces immediately above cargo tanks provided it be housed in a special compartment with boundaries which are gastight towards the 'tween deck space and has a cofferdam between its floor and the cargo tanks. Access is to be solely from the deck above and the compartment is to be adequately ventilated. Cables are not to be attached directly to the bulkheads or floor, and section boards are not to be located in this compartment.

Plans showing the construction of the compartment, the electrical apparatus to be housed therein, and the provisions for ventilation are to be submitted.

Section 16

SECONDARY BATTERIES

General

1601 Secondary batteries installed permanently in position, except small batteries of portable types, are to comply with the requirements of this Section. The term "battery compartment" implies any compartment, recess or locker occupied by secondary batteries.

Construction

1602 The cells of secondary batteries are to be so constructed as to prevent spilling of the electrolyte due to the motion of the ship and prevent the emission of acid or alkaline spray on to surrounding objects. The containers are to be of strong construction and of non-brittle material; they are not to be of celluloid. The plates are to be of such dimensions and so arranged that they are firmly secured against motion within the containers.

Arrangement

1603 Every battery is to be so arranged that each cell or crate of cells is readily accessible from the top and from at least one side; the cells are, if possible, to be arranged in a single tier. The cells or crates are to be carried on insulators which are either to be integral with them or be separate components of glass, vitreous porcelain, ebonite, rubber, or equivalent material; insulators of similar material are to be employed to prevent any movement of the cells arising from the motion of the ship.

Position of Battery Compartment

1604 The position of the battery compartment is to be such that no magnetic compass is affected by currents in the battery or in any conductors connected thereto.

The battery is to be located in such a position that it is not liable to be subjected to extremes of temperature.

Protection of Battery Compartment

1605 Where acid is used as the electrolyte for the battery, the deck below the cells is to be so protected with lead or other acid-resisting material as effectually to prevent any acid from lodging in contact with the structure of the ship. All metalwork within the battery compartment, including exposed metal on the battery and its connections, is to be protected with acid-resisting paint, unless such metalwork, by virtue of its composition or arrangement, or for other reasons, is not subject to the deleterious effects of acid.

Ventilation of Battery Compartment

1606 The battery compartment is to be suitably ventilated so that it is impossible for battery gases to accumulate in appreciable quantities during periods of charging, discharging or standing on open circuit.

Naked Lights

1607 A permanent notice is to be exhibited prohibiting naked lights and smoking in the vicinity of the battery.

Control

1608 Suitable means, including an ammeter and a voltmeter, are to be provided for controlling the current with which a battery is to be charged and to protect against accidental discharge into the charging circuit.

1609 Switches, fuses and other electrical equipment liable to cause an arc are not to be placed within the battery compartment. The battery cables are to be protected by a fuse in each conductor at a position adjacent to the battery compartment.

Section 17

COLD CATHODE LUMINOUS DISCHARGE LIGHTING

NOTE.—This section applies to cold cathode luminous discharge tubes having a normal operating voltage in excess of 250 volts.

General

1701 External electric signs are not to be installed in a position where they are likely to obscure or be mistaken for any navigation light specified in the International Regulations for Preventing Collisions at Sea.

1702 The earthing of electric signs is to be carried out in compliance with M 409. It is not necessary to earth metal clips or clamps used in positions remote from the terminals to support luminous-discharge-tubes, unless it is found desirable to effect the earthing of such clips or clamps in order to reduce interference with radio reception.

1703 Every motor and other mains-operated apparatus employed for switching or flashing of electric signs is to be connected to an independent final sub-circuit.

Installations

1704 Every luminous-discharge-tube installation, in addition to complying with such requirements of 1701 to 1703 as are applicable, is to comply with the requirements of 1705 to 1708.

1705 The voltage of primary circuits is not to exceed that permitted for ordinary lighting circuits.

1706 The secondary or high-voltage circuit is to be permanently earthed at the transformer, and the core of every transformer is to be earthed.

1707 Irrespective of the method of obtaining the voltage of the circuit which feeds the luminous-discharge-tubes, all parts of such circuit are to be isolated from the supply.

1708 Notices, made of durable material that will be unaffected by the weather and in size each not less than 18 square inches are to be set up and maintained at points of access to the luminous-discharge-tubes, and where otherwise necessary. The notices are to bear the following wording :—

DANGER
SWITCH TO BE LOCKED IN THE OFF POSITION BEFORE TOUCHING

The word "DANGER" is to be in large red letters and the word "LOCKED" is to be emphasised. The remainder of the lettering is to be either black or white, depending on the colour of the plate.

Enclosure of Live Parts

1709 In addition to the requirements of 1704 to 1708, fixed interior luminous-discharge-tube devices are to have all live metal parts enclosed in a suitable earthed case constructed of metal or lined with metal, such case being sealed and marked with the word "DANGER" on or near the seal.

Submission of Plans

1710 Full details of every luminous-discharge-tube installation, showing the position of all devices in connection therewith, the arrangement of circuits and locked switches and details of construction are to be submitted for approval.

Section 18

INTERNAL COMMUNICATIONS

Construction of Transforming Plant

1801 Motor-generators and static transformers used for the reduction of voltage for communication circuits, together with their control gear, are to comply with the clauses for similar plant employed for lighting and power supply.

Batteries

1802 Primary and secondary batteries are to be readily accessible at all times, and means are to be provided to prevent liquid from the cells coming into contact with the wooden floor or the structure of the ship. Secondary batteries are, in addition, to comply with such requirements of M 16 as are applicable.

Construction of Apparatus

1803 Where a communication system derives its supply from the lighting and/or power circuits, or where the voltage of supply exceeds 55 volts, all cables, wires, switches, resistors, distribution fuse-boards, accessories, instruments, and other apparatus comprising such system, are to be designed, constructed and fitted throughout in all respects in accordance with such of the requirements for lighting and power circuits as are applicable.

1804 Where a communication system derives its supply from motor-generators, primary or secondary batteries, or static transformers, and is entirely electrically isolated from the lighting and power circuits, and the voltage of supply does not exceed 55 volts, all switches, resistors, distribution fuse-boards, accessories, instruments, and other apparatus in connection therewith, are to be of robust design and construction, and so installed as to ensure an ample margin of safety, having regard to the voltage employed.

1805 All materials and appliances, whether the conditions of service are as named in 1803 or 1804, are to conform with the remaining requirements of these Rules as far as applicable.

Cables

1806 Cables used for the purpose of internal communication are to be of one or other of the types specified in M 701 to M 705, except that vulcanised-

rubber-insulated cables and cables having fire-resisting insulation (R.N.N. type) of conductor size 1/·036 in. may be used and are to be fitted in a similar manner to cables installed for the lighting and power supply of the ship, and they are to be kept separate from the latter, unless the lighting and power cables and/or the communication cables are protected by lead-alloy sheathing or sheathing of the H.R. type.

1807 Communication cables run in wood casing are not to be fixed in the same groove as the cables of lighting and power circuits.

Protection of Circuits

1808 Communication circuits, other than those supplied from primary batteries, are to be protected on each insulated pole by fuses of a current rating suited to the maximum current rating of the circuit to be protected.

Identification

1809 Communication circuits are to be so arranged and terminal boxes so designed, fitted, labelled, or otherwise marked to facilitate identification, as to enable fault-testing to be expeditiously carried out and the necessary repairs to be made with the minimum possible disturbance to other circuits.

Alarm and Bell Circuits

1810 The circuits and apparatus of electric alarms are to comply with the requirements of 1803.

Section 19

LIGHTNING CONDUCTORS

General

1901 Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.

Construction

1902 In wood and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 0·15 square inch which are to be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 0·5 inch in diameter, projecting at least 6 inches above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 0·5 inch diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate not less than 2 square feet in area, fixed well below the light waterline and attached to the ship's side in such a manner that it is to be immersed under all conditions of heel.

1903 In wood and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with 1902, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

1904 In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in 1902. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

1905 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. No connection is to be dependent on a soldered joint.

1906 The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0·02 ohms.

Protection when in Dry Dock

1907 It is recommended suitable means should be provided to enable ships when in dry dock or on a slipway to have their lightning conductors connected to an efficient earth on shore. All floating docks should be provided with appropriate means of earthing the lightning conductors of a vessel supported thereon.

Section 20

CONSTANT-CURRENT SERIES SYSTEMS

Working Voltage

2001 The working voltage of any constant-current series system is not to exceed 650 volts.

Generators and Motors

2002 Generators and motors are not to be of the open type.

2003 Every motor is to be so protected that its speed cannot exceed a predetermined safe limit.

Switchgear

2004 An automatic device is to be provided with every generator to reduce its voltage to zero in the event of any open circuit occurring at any part in the system. This device is not to be applied to short circuit the generators.

2005 When more than one generator is fitted, each such machine is to be provided with a double-pole selector switch arranged to connect the generator in series with the system or alternatively to isolate the generator by short circuiting the machine after reducing its voltage to zero, completing the continuity of the circuit and disconnecting the machine.

2006 All distribution switches are to be capable of effecting the same operations as the generator selector switches (*see* 2005).

2007 Every current-consuming device is to be provided with a main switch, which is to isolate the device from the system without breaking the main circuit.

2008 Every motor is to be provided with a by-pass switch which is to automatically short circuit the motor terminals when its armature is at rest and the controller is at zero speed position.

Earthing

2009 No part of the system is to be earthed.

Section 21

ELECTRO-MAGNETIC COUPLINGS

General

2101 In ships in which power for propulsion purposes is transmitted either wholly or partially by means of electro-magnetic couplings they are to be constructed under special survey and tested in the presence of the Surveyors.

Plans

2102 In order to facilitate the inspection, plans in triplicate are to be submitted for consideration before the work is commenced. The plans are to show the scantlings and construction of the main units intended for the transmission of power and details of the electrical components, switchgear and control gear.

Rating, Construction and Installation of Couplings

2103 The relevant requirements of L 5 and L 6 are to apply.

Discharge Protection

2104 Effective means are to be provided for limiting the induced voltage when field circuits are opened, in order to protect the field windings and associated cables, switchgear and control gear and the main busbars.

Magnetic Air Gaps in Slip-Couplings

2105 Provisions are to be made to facilitate the periodical checking of the magnetic air gap, and gauges are to be supplied for this purpose. The estimated out-of-balance pull due to eccentricity of the air gap is to be stated when submitting the plans for consideration.

Mechanical Protection

2106 Adequate protection is to be provided to prevent the ingress of foreign bodies, particularly of magnetic material.

Magnetic Centre

2107 The position of magnetic centre of slip-couplings is to be predetermined and the couplings are to be assembled in the ship in correct position so that there is no appreciable axial thrust between the two halves of the coupling when in service.

Testing

2108 Unless otherwise approved, every coupling is to be tested at the maker's works in the presence of the Surveyors.

The tests are to include :—

Temperature tests at such speed or speeds, and with torques corresponding with the estimated service torques, as may be approved to ensure conformity with the prescribed limits of temperature rise.

An overspeed test for three minutes at a speed 25 per cent above the maximum service speed.

Determination of magnetic centre of slip-couplings.

Insulation resistance.

High voltage test.

Section 22

SUPPRESSION OF RADIO INTERFERENCE

General

2201 Where measures are taken to suppress interference with radio services components fitted to circuits, apparatus, motors or generators employed on essential services are to comply with this Section.

2202 Components other than capacitors are to be suitable for use under tropical conditions, salt-laden atmospheres and in a cooling air temperature of 113° F. (45° C.) in machinery spaces and 104° F. (40° C.) elsewhere. Where they are fitted in machines or appliances they are to be suitable for the temperatures which prevail in such apparatus under working conditions, whether due to direct radiation from the windings, from the heated air, or by thermal conduction.

2203 Capacitors are to be suitable for continuous working in surroundings having ambient temperatures between —40° F. (—40° C.) and 185° F. (85° C.) and in atmospheres of 100 per cent relative humidity. The voltage rating of the capacitor is to be not less than the normal voltage to which it will be subjected in service and is to be such that this voltage causes no deterioration in its electrical properties.

The terminal insulation is to be such as to have long life with continuous use, terminals which do not use organic materials being preferred. The creepage distance between any two terminals over an exposed surface or between any terminal and an exposed conducting surface such as the case of the capacitor, if metallic, is to be not less than the following :—

Over the surface of insulant ... $(2 + \frac{U}{250})$ mm.

Across an air gap ... ... $(2 + \frac{U}{500})$ mm.

Where U is the rated voltage of a D.C. rated capacitor or $U = \sqrt{2}E$ in the case of A.C. rated capacitors, E being the RMS voltage. Fractions of a millimetre are to be counted as one mm.

Any impregnating or filling compounds are to be of a substantially non-polar nature, i.e., are to have a dielectric constant not exceeding 3.

Paper dielectric capacitors are to have at least three layers of paper separating the electrodes, each layer of a nominal thickness not less than 9 microns, and the working stress, defined as the rated voltage (or 1·41 times the RMS voltage in the case of A.C.) divided by the total nominal thickness of the dielectric, is not to exceed 8·5 volts per micron.

Containers and terminal entries are to be such that they remain permanently hermetically sealed and are to be corrosion-proof under working conditions.

The insulation resistance between terminals corrected to 20° C. is to be not less than 5,000 ohmfarads for capacitors of 0·1 microfarads and over and not less than 50,000 megohms for capacitors less than 0·1 microfarads. (Ohmfarads will be the product of the insulation resistance in megohms and the capacitance in microfarads.)

The insulation resistance between terminals and adjacent conducting surfaces in metal-cased capacitors in which the case is not electrically connected to an electrode is to be not less than 1,000 megohms when tested at 500 volts D.C.

All capacitors are to withstand without detriment the application of a D.C. voltage equal to 6U in the case of capacitors for D.C. use or 8·5E for A.C. use applied between terminals and also between terminals and case, if of metal, and insulated from the electrodes for not less than one nor more than five seconds.

2204 Where capacitors are fitted to the main busbars, main and emergency generators or steering gear, fuses of appropriate category are to be connected in the capacitor circuit.

Section 23

TRIALS

General

2301 Before a new installation or alterations or additions to an existing installation are put into service, the appropriate trials specified in this Section are to be made. Such trials are to be in addition to, and not in substitution for, the acceptance trials of the individual items of plant at the makers' works.

Testing Voltage

2302 The voltage used for the insulation-resistance tests referred to in 2304 to 2307 inclusive is to be direct-current voltage not less than twice that to which the circuits will normally be subject (twice the root-mean-square value if the supply is alternating-current), provided that it need not exceed 500 volts for circuits normally not exceeding 650 volts.

Insulation Resistance of Completed Installation

2303 Before a completed installation, or an addition to an existing installation, is put into service, the insulation resistance to earth of every distribution circuit is to be not less in megohms than 50 divided by the number of outlets (points and switches) from the fixed wiring, except that it need not exceed 1 megohm. The test is to be made with all fuse-links in place, all switches (except the supply switch) closed, and, except with systems having one pole of the supply permanently earthed, all lamps in position or both poles of the installation otherwise electrically connected together.

2304 When the insulation-resistance of an installation or section of an installation is found by a 500-volt instrument to be below 0·5 megohm, the installation is to be so subdivided, for the purposes of the test, that the insulation-resistance of each section is not less than 0·5 megohm.

Switchboards, etc.

2305 Before a main switchboard, emergency switchboard, or section board, is put into service, the insulation resistance is to be not less than 1 megohm, when measured between each insulated busbar and earth, and between each insulated busbar and the busbar connected to the other pole or poles.

The test is to be made with all circuit-breakers and switches in the open position and all fuse-links for pilot lamps, earth lamps, voltmeters, etc., removed. Voltage coils and potential transformers normally connected to the busbars are to be temporarily disconnected while the test between poles is being made.

Heating and Power Appliances

2306 During the test of any circuit, control rheostats and heating and power appliances normally connected to the circuit may, if desired, be disconnected; but in that event the insulation resistance between the case and/or framework and all live parts of every rheostat and appliance is to be not less than half a megohm.

Testing Between Conductors

2307 Where practicable, the insulation resistance is also to be measured between all the conductors connected to each pole of the supply and all the conductors connected to the other pole or poles or to the middle wire or the neutral; and its value is not to be less than that specified in 2304.

Testing Polarity of Fuses and Single-Pole Switches

2308 Precautions are to be taken to verify that no fuse, non-linked switch, or non-linked circuit-breaker, has been connected to that pole of a circuit which is either earthed or derives its polarity from an earthed conductor.

Testing Earth Continuity

2309 Where lead-alloy-sheathed cables or armoured cables are employed, tests are to be made where necessary to verify that all metallic envelopes are electrically continuous throughout their length, and are earthed as required by M 918.

2310 Tests shall be made to verify that all earth continuity conductors and earthing leads are connected to the frames of the fittings and appliances, and to the hull of the ship, and that in socket-outlets having earthing contact-tubes, the latter are also connected to the hull.

Insulation Resistance of Generators and Motors

2311 The insulation resistance in megohms of every completed generator and motor in normal working condition and with all parts in place is not to be less than

$$\frac{3 \times \text{Rated Voltage of Machine}}{1{,}000 + \text{Rated Output of Machine in kVA}}$$

All insulation tests are, where possible, to be made when the generators and motors are hot.

2312 The insulation resistance of generator cables, motor cables, field windings, and control gear, when isolated and separated for testing purposes, is not to be less than 1 megohm.

Generating Sets, Switchgear and Connections

2313 It is to be demonstrated that the relevant requirements of these Rules have been complied with in respect of the following :—

The satisfactory commutation and performance of every generator throughout a run at full rated load.

The temperatures of all joints and connections, fuses, circuit-breakers, and busbars.

The operation of engine speed governors, synchronising devices, over-speed trips, generator reverse-current or reverse-power and over-current trips, preference trips and other safety devices.

The voltage regulation of every generator, when full rated load is suddenly thrown off by operating the circuit-breaker or main switch (*see* M 210, M 212 and M 217.

The satisfactory operation in parallel, load sharing, etc., of all generators capable of being run in parallel with a load on the busbars of not less than 1½ times the full load rating of the largest generator.

Motors

2314 Every motor (with its control gear) is to be run under service conditions for a sufficient length of time to demonstrate that its wiring, alignment, size, direction of rotation, speed, commutation and temperature, are satisfactory.

Apparatus and Voltage Drop

2315 All lamps, heaters and other appliances are to be run, though not necessarily under full load or simultaneously. Tests of voltage and operation are to be made, if necessary, to verify compliance with M 218 and M 617 (voltage drop).

Section 24

SPARE GEAR

2401 For the efficient operation of ships engaged in open sea service the articles of spare gear mentioned in the following paragraphs, so far as they are applicable, should be supplied. Owners should arrange to replace or make good used items as opportunity occurs.

2402 Generators.—For each size of generator :—

1 set of carbon brushes for one machine.

1 set of any special spanners required.

2403 Motors.—For each size of motor engaged on essential services, such as those enumerated below :—

1 set of carbon brushes for one machine.

1 set of any special spanners required.

The following are regarded as essential services :—

Air compressors for heavy oil engines.

Scavenge blowers.

Air pumps.

Ballast pumps.

Bilge pumps.

Circulating and cooling water pumps.

Condenser circulating pumps.

Extraction pumps.

Feed water pumps.

Fire pumps.

Fuel valve cooling pumps.

Lubricating oil pumps.

Oil fuel pumps and oil fuel burning units.

Cargo refrigerating motors, including compressors, brine pumps, circulating pump, fans, etc.

Fans for forced draught to boilers.

Steering gear.

Windlasses.

Ventilating fans for engine room and boiler rooms.

2404 Steering Gear.—For each size of steering gear motor and motor-generator, if no standby machine is installed, the following spare gear is required in addition to the spares for motors enumerated in 2403 :—

1 spare armature of each size fitted, complete with shaft and half coupling.

1 spare field coil of each type fitted.

Where electric steering gear is fitted and there is no standby generator, similar spare gear is also to be provided for the generator.

2405 Fans for Refrigerating Equipment.—For electrically driven air circulating fans the following spare gear will be required, in addition to the spares enumerated in 2403, for each size of motor installed, except where a duplicate fan motor, ready for use, is installed in accordance with N 363 :—

1 motor complete, or

1 armature complete

1 complete set of field coils

1 complete set of brush gear

1 set of bearings

2406 Control Gear.—For the starting gear of motors, such as those enumerated in 2403 :—

1 set of contacts which are subject to burning or wear.

1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of shunt coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

2407 Switchgear and Distribution Boards.—For each type of circuit-breaker on each pole :—

1 set of contacts which are subject to burning or wear.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

10 per cent but not less than 12 of each type of cartridge or other non-renewable fusible cut-out.

Rewireable fuse-handles; 5 per cent, with a minimum of one, of each size or type used, provided that not more than 12 need be supplied.

2408 Navigating and Signal Lights, and their pilot lamps for indicating devices :—

1 complete spare set of lamps.

2409 Emergency Lighting. — Where supplied from storage batteries of a voltage different from the ship's circuit :—

1 complete spare set of lamps.

2410 Mineral-Insulated Copper-Sheathed Cables.—Where ocean going ships are wired to any appreciable extent with mineral-insulated copper-sheathed cables suitable spares are to be carried. Following is an indication of the type of spares required for an average installation :—

Description	Suggested Quantity
Insulating Sleeve.	Not less than 12 feet of each size and colour.
Sealing Compound.	1 lb. of each type used.
Tools.	One set of any special tools required for the preparation of cable ends and the making of seals.
Sealing Components.	Sufficient details for making 12 of each size and type of seal used.
Compression Rings for Gland Seals.	6 of each size required.
Cable.	In large installations spare lengths of cable may also be advisable.
Installation Instructions.	One copy of the maker's recommendations.

2411 Electro-Magnetic Couplings.—For each size of electro-magnetic coupling used for propulsion purposes, a list of spare gear for the couplings and their associated control gear is to be submitted for consideration.

This is to include the following as a minimum :—

1 complete set of brush gear.

1 field coil of each type fitted.

1 set of brushes for one coupling.

1 gauge for checking the magnetic air gap.

Spares for the control gear and switchgear as above.

2412 **Electronic Gear.**—Where electronic gear essential for the operation of an essential service is fitted suitable spares are to be supplied and a list of such spares submitted in advance for approval. Items such as electronic valves, capacitors, rectifiers, etc., should be included.

2413 **Storage and Packing.**—All spare electrical gear is to be suitably packed to resist deterioration and stored in dry situations.

2414 **Insulation Tester.**—It is recommended that a 500 volt insulation tester be provided with all equipment of 100 kW and above for the testing of insulation and tracing of faults and that all parts of the system be periodically tested and the results recorded.

Section 25

PERIODICAL SURVEYS

The requirements as to periodical surveys of electrical equipment are set forth in C 7.

9th December, 1954.

TABLE I

Current Rating for Single and Twin-Core Vulcanised-Rubber-Insulated Cables*

Conductor		Cooling-air temperature up to 104° F. (40° C.)			Cooling-air temperature up to 113° F. (45° C.)		
		Current rating‡	Approximate length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 3		Current rating‡	Approximate length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 6	
Nominal cross-sectional area	Number and diameter (in.) of Wires	D.C. or Single-phase A.C.	D.C.	Single-phase A.C.	D.C. or Single-phase A.C.	D.C.	Single-phase A.C.
1	2	3	4	5	6	7	8
sq. in.		amps.	feet	feet	amps.	feet	feet
0·0015	1/·044	5	33	33	4	41	41
0·002	3/·029	5	42	42	4	53	53
0·003	3/·036	10	33	33	7	47	47
0·003	1/·064	10	35	35	7	50	50
0·0045	7/·029	15	33	33	11	45	45
0·007	7/·036	24	32	32	17	45	45
0·01	7/·044	31	37	37	22	52	52
0·0145	7/·052	37	43	43	27	59	59
0·0225	7/·064	46	53	53	33	73	73
0·03	19/·044	53	58	58	38	82	81
0·04	19/·052	64	68	67	46	94	93
0·06	19/·064	83	79	76	60	109	105
0·1	19/·083	118	93	87	85	130	121
0·15	37/·072	152	106	97	110	147	134
0·2	37/·083	184	117	97	133	161	135
0·25	37/·093	214	126	97	155	174	134
0·3	37/·103	240	138	99	174	190	136
0·4	61/·093	288	154	96	208	214	133
0·5	61/·103	332	164	89	240	227	123
		D.C. A.C.			D.C. A.C		
0·75	91/·103	461 425	176	76	334 308	244	106
1·0	127/·103	595 520	191	68	430 376	264	94

* Including cables with fire-resisting insulation (R.N.N. type), polychloroprene-compound-sheathed (H.R. type) cables and lead-alloy-sheathed cables.

‡ These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded. See also Appendix 9.

TABLE II

Current Ratings for Three-Core Vulcanised-Rubber-Insulated Cables*

Conductor		Cooling-air temperature up to 104° F. (40° C.)		Cooling-air temperature up to 113° F. (45° C.)	
Nominal cross-sectional area	Number and diameter (in.) of wires	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 3	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 5
1	2	3	4	5	6
sq. in.		amps.	feet	amps.	feet
0·002	3/·029	5	42	4	53
0·003	3/·036	10	33	7	47
0·003	1/·064	10	35	7	50
0·0045	7/·029	15	33	11	45
0·007	7/·036	17	45	12	64
0·01	7/·044	22	52	16	71
0·0145	7/·052	26	61	19	84
0·0225	7/·064	32	76	23	105
0·03	19/·044	37	84	27	115
0·04	19/·052	45	96	33	130
0·06	19/·064	58	111	42	154
0·1	19/·083	83	128	60	177
0·15	37/·072	106	141	77	194
0·2	37/·083	129	147	93	204
0·25	37/·093	150	150	109	206
0·3	37/·103	168	153	122	211
0·4	61/·093	202	150	146	208
0·5	61/·103	232	143	168	198

* Including cables with fire-resisting insulation (R.N.N. type) polychloroprene-compound sheathed (H.R. type) cables and lead alloy sheathed cables.

† These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded. See also Appendix 9.

TABLE III

CURRENT RATINGS FOR SINGLE-CORE IMPREGNATED PAPER OR VARNISHED-CAMBRIC-INSULATED LEAD-ALLOY SHEATHED† CABLES

Conductor		Cooling-air temperature up to 104° F. (40° C.)			Cooling-air temperature up to 113° F. (45° C.)		
		Current rating‡	Approximate length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 3		Current rating‡	Approximate length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 6	
Nominal cross-sectional area	Number and diameter (in.) of wires	D.C. or Single-phase A.C.	D.C.	Single-phase A.C.	D.C. or Single-phase A.C.	D.C.	Single-phase A.C.
1	2	3	4	5	6	7	8
sq. in.		amps.	feet	feet	amps.	feet	feet
0·0015	1/·044	5	31	31	5	31	31
0·002	3/·029	5	40	40	5	40	40
0·003	3/·036	10	31	31	10	31	31
0·003	1/·064	10	33	33	10	33	33
0·0045	7/·029	15	31	31	15	31	31
0·007	7/·036	30	24	24	27	26	26
0·01	7/·044	45	24	24	41	26	26
0·0145	7/·052	60	25	25	55	27	27
0·0225	7/·064	80	28	28	72	31	31
0·03	19/·044	92	31	31	84	34	34
0·04	19/·052	110	37	37	101	40	40
0·06	19/·064	143	43	42	130	47	46
0·1	19/·083	202	51	47	185	56	51
0·15	37/·072	260	58	53	238	63	58
0·2	37/·083	314	64	53	286	70	58
0·25	37/·093	363	69	55	331	76	61
0·3	37/·103	408	76	56	372	83	61
0·4	61/·093	492	84	56	448	93	62
0·5	61/·103	572	89	52	522	98	57
		D.C. A.C.			D.C. A.C.		
0·6	91/·093	660 625	94	50	605 572	102	54
0·75	91/·103	782 710	97	46	713 648	107	51
1·0	127/·103	987 842	107	43	900 768	118	47

† For ratings of polychloroprene (e.g. neoprene) sheathed cables *see* Table V.

‡ These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded. See also Appendix 9.

TABLE IV

Current Rating for Three-Core Impregnated Paper or Varnished-Cambric-Insulated Lead-Alloy Sheathed Cables*

Conductor		Cooling-air temperature up to 104°F. (40°C.)		Cooling-air temperature up to 113°F. (45°C.)	
Nominal cross-sectional area	Number and diameter (in.) of wires	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 3	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 5
1	2	3	4	5	6
sq. in.		amps.	feet	amps.	feet
0·003	3/·036	10	31	9	34
0·0045	7/·029	15	31	14	33
0·007	7/·036	21	34	19	38
0·01	7/·044	32	33	29	37
0·0145	7/·052	42	36	38	39
0·0225	7/·064	56	40	51	44
0·03	19/·044	64	45	58	50
0·04	19/·052	77	52	70	57
0·06	19/·064	100	60	91	66
0·1	19/·083	141	71	128	78
0·15	37/·072	182	78	166	86
0·2	37/·083	220	84	200	92
0·25	37/·093	254	87	231	96
0·3	37/·103	286	90	260	99
0·4	61/·093	344	90	313	99
0·5	61/·103	400	86	364	95

* For ratings of polychloroprene (e.g. neoprene) sheathed cables *see* Table V (a).

† These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded. See also Appendix 9.

TABLE V

Current Rating for Single-core Varnished-Cambric-Insulated Polychloroprene (*e.g.* Neoprene) Sheathed Cables

Conductor		Cooling-air Temperature up to 104° F. (40°C.)			Cooling-air Temperature up to 113° F. (45° C.)		
Nominal cross-sectional area	Number and diameter (in.) of wires	Current rating* D.C. or Single-phase A.C.	Approx. length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 3		Current rating* D.C. or Single-phase A.C.	Approx. length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 6	
			D.C.	Single-phase A.C.		D.C.	Single-phase A.C.
1	2	3	4	5	6	7	8
sq. in.		amps.	feet	feet	amps.	feet	feet
0·007	7/·036	31	23	23	27	26	26
0·01	7/·044	41	26	26	36	30	30
0·0145	7/·052	48	31	31	42	35	35
0·0225	7/·064	61	37	37	53	42	42
0·03	19/·044	72	40	40	63	45	45
0·04	19/·052	88	46	46	77	52	52
0·06	19/·064	115	53	52	100	61	60
0·1	19/·083	161	64	59	141	73	67
0·15	37/·072	204	74	67	178	84	77
0·2	37/·083	246	82	68	215	93	77
0·25	37/·093	287	87	70	251	100	80
0·3	37/·103	326	95	70	285	108	80
0·4	61/·093	399	104	69	349	119	80
0·5	61/·103	458	111	65	400	128	74
		D.C. A.C.			D.C. A.C.		
0·6	91/·093	519 500	120	62	453 437	137	71
0·75	91/·103	594 565	128	58	519 494	147	67
1·0	127/·103	746 685	142	53	652 599	163	60

* These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded. See also Appendix 9.

TABLE V (a)

Current Rating for Three-Core Varnished-Cambric-Insulated Polychloroprene (e.g. Neoprene) Sheathed Cables.

Conductor		Cooling-air temperature up to 104° F. (40° C.)		Cooling-air temperature up to 113° F. (45° C.)	
Nominal cross-sectional area	Number and diameter (in.) of wires	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 3	Current rating† 3-phase A.C.	Approx. length in circuit (*lead only*) for 1-volt drop to neutral for balanced 3-phase A.C. with current rating in Col. 5
1	2	3	4	5	6
sq. in.		amps.	feet	amps.	feet
0·007	7/·036	24	31	21	34
0·01	7/·044	31	34	27	40
0·0145	7/·052	36	42	32	46
0·0225	7/·064	45	50	39	57
0·03	19/·044	53	54	46	63
0·04	19/·052	66	60	58	69
0·06	19/·064	84	71	73	82
0·1	19/·083	118	85	103	98
0·15	37/·072	151	94	132	108
0·2	37/·083	181	102	158	116
0·25	37/·093	209	106	183	121
0·3	37/·103	239	107	209	123
0·4	61/·093	287	110	251	125
0·5	61/·103	328	105	287	117

† These current ratings are subject to the maximum permissible voltage drop (*see* M 615 and M 617) not being exceeded.
See also Appendix 9

TABLE VI

DIRECT CURRENT OR SINGLE-PHASE A.C. CURRENT RATINGS* FOR INTERMITTENTLY-LOADED SINGLE CORE CABLES

Conductor		Vulcanised-rubber-insulated cables		Impregnated-paper-insulated cables and varnished-cambric-insulated lead alloy sheathed cables		Varnished-cambric insulated polychloroprene sheathed cables	
Nominal cross-sectional area	Number and diameter (in.) of wires	Current† for half-hour rating	Current† for one-hour rating	Current† for half-hour rating	Current† for one-hour rating	Current† for half-hour rating	Current† for one-hour rating
1	2	3	4	5	6	7	8
sq.in.		amps.	amps.	amps.	amps.	amps.	amps.
0·0145	7/·052	38	37	63	60	50	48
0·0225	7/·064	47	46	84	80	64	61
0·03	19/·044	56	54	99	93	78	73
0·04	19/·052	68	65	119	111	95	89
0·06	19/·064	92	85	160	146	129	117
0·1	19/·083	142	124	238	210	190	167
0·15	37/·072	191	164	320	276	250	216
0·2	37/·083	247	204	400	340	312	265
0·25	37/·093	300	244	475	400	374	315
0·3	37/·103	351	283	565	460	442	368
0·4	61/·093	452	357	700	575	568	466
0·5	61/·103	534	422	850	685	680	550
		D.C. A.C.	D.C. A.C.	D.C. A.C.	D.C. A.C.	D.C. A.C.	D.C. A.C.
0·75	91/·103	774 715	604 556	1,250 1,130	990 900	950 900	750 710

* These values are subject to the maximum permissible voltage drop (*see* M 617) not being exceeded. The approximate length in circuit (*lead plus return*) for 1 volt drop will be the corresponding length given in Tables I and III respectively multiplied by the continuous rating in amperes and divided by the intermittent rating.

† Cooling-air temperature up to 104° F. (40° C.).

TABLE VII

Current Rating and Radial Thickness of Dielectric for Twin Flexible Cords and Flexible Cables

Conductor		Current rating*	Approximate length in circuit (*lead plus return*) for 1-volt drop with current rating in Col. 3	Radial thickness of insulation	
Nominal cross-sectional area	Number and diameter (in.) of wires			250-volt Cables	660-volt Cables
1	2	3	4	5	6
sq. in.		amps.	feet	in.	in.
0·0006	14/·0076	2	53	0·033	—
0·001	23/·0076	3	59	0·034	—
0·0017	40/·0076	5	57	0·035	—
0·003	70/·0076	10	50	0·036	—
0·0048	110/·0076	15	48	0·038	—
0·007	162/·0076	20	48	0·039	—
0·01	97/·012†	25	49	0·043	0·060
0·0145	60/·018†	30	58	0·046	0·061
0·0225	91/·018†	37	70	0·049	0·062

* These current ratings are subject to the maximum permissible voltage drop not being exceeded.

† For trailing cables and similar purposes.

TABLE VIII

DIMENSIONS OF 250 VOLT VULCANISED-RUBBER-INSULATED AND FIRE-RESISTING (R.N.N. TYPE) CABLES

Conductors		D	Thickness of lead-alloy sheath			Diameter of armouring wire single-core*	Thickness of H.R. sheath		
Nominal cross sectional area	Number and diameter (in.) of wires	Thickness of insulation	Single-core	Twin-core. Circular	Three-core.† Circular		Single-core	Twin-core	Three-core
1	2	3	4	5	6	7	8	9	10
sq. in.		in.	in.	in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·03	0·04	0·04	—	—	0·04	—	—
0·002	3/·029	0·03	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·003	1/·064	0·03	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·003	3/·036	0·03	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·0045	7/·029	0·03	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·007	7/·036	0·035	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·010	7/·044	0·035	0·04	0·05	0·05	0·048	0·04	0·05	—
0·0145	7/·052	0·04	0·04	0·06	0·06	0·048	0·04	0·05	—
0·0225	7/·064	0·04	0·05	0·06	0·06	0·048	0·05	0·06	—
0·030	19/·044	0·045	0·05	0·06	0·06	0·048	0·05	—	—
0·040	19/·052	0·05	0·05	0·075	0·075	0·048	0·05	—	—
0·060	19/·064	0·055	0·05	0·075	0·075	0·064	0·05	—	—

*For determining the sizes of armouring wire for twin-core, three-core and multicore cables see Table XVI.

†The thickness of lead-alloy sheath on multicore cables in which the conductors are not of equal area is to be the same as that for a similar cable having conductors equal in area to that of the largest of the unequal conductors.

D is the thickness of the insulation as follows:—

(1) On the conductor of single-core cables.

(2) On each conductor of twin and three-core cables.

TABLE IX

DIMENSIONS OF 660 VOLT VULCANISED-RUBBER-INSULATED AND FIRE-RESISTING (R.N.N. TYPE) CABLES

Conductors		D Thickness of insulation	Thickness of lead-alloy sheath			Diameter of armouring wire Single-core*	Thickness of H.R. sheath		
Nominal cross-sectional area	Number and diameter (in.) of wires		Single-core	Twin-core circular	Three-core† circular		Single-core	Twin-core	Three-core
1	2	3	4	5	6	7	8	9	10
sq. in.		in.	in.	in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·055	0·04	0·05	—	0·048	0·04	—	—
0·002	3/·029	0·055	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·003	1/·064	0·055	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·003	3/·036	0·055	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·0045	7/·029	0·055	0·04	0·05	0·05	0·048	0·04	0·05	0·05
0·007	7/·036	0·06	0·04	0·05	0·06	0·048	0·04	0·05	0·06
0·01	7/·044	0·06	0·05	0·06	0·06	0·048	0·05	0·06	—
0·0145	7/·052	0·06	0·05	0·06	0·06	0·048	0·05	0·06	—
0·0225	7/·064	0·06	0·05	0·06	0·06	0·048	0·05	0·06	—
0·03	19/·044	0·06	0·05	0·06	0·075	0·048	0·05	—	—
0·04	19/·052	0·065	0·05	0·075	0·075	0·064	0·05	—	—
0·06	19/·064	0·065	0·05	0·075	0·09	0·064	0·05	—	—
0·1	19/·083	0·07	0·06	0·09	0·09	0·064	0·06	—	—
0·15	37/·072	0·08	0·06	0·10	0·10	0·064	0·06	—	—
0·2	37/·083	0·09	0·075	0·11	0·11	0·080	0·075	—	—
0·25	37/·093	0·095	0·075	0·11	0·12	0·080	0·075	—	—
0·3	37/·103	0·10	0·075	0·12	0·12	0·104	0·075	—	—
0·4	61/·093	0·11	0·09	0·12	0·13	0·104	0·09	—	—
0·5	61/·103	0·12	0·09	0·13	0·13	0·104	0·09	—	—
0·75	91/·103	0·13	0·10	—	—	0·104	0·10	—	—
1·0	127/·103	0·14	0·11	—	—	0·104	0·11	—	—

* For determining the sizes of armouring wire for twin-core, three-core and multicore cables see Table XVI.

† The thickness of lead on multicore cables in which the conductors are not of equal area is to be the same as that for a similar cable having conductors equal in area to that of the largest of the unequal conductors.

D is the thickness of the insulation as follows:—

(1) On the conductor of single-conductor cables.

(2) On each conductor of twin- and three-core cables.

TABLE X

Dimensions of 250 Volt Vulcanised-Rubber-Insulated, Tough-Rubber-Sheathed Cables

Conductors		Thickness of insulation*	Thickness of tough rubber sheath		
Nominal cross-sectional area	Number and diameter (in.) of wires		Single-core*	Twin-core circular†	Three-core circular†
1	2	3	4	5	6
sq. in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·03	0·04	0·04	0·04
0·002	3/·029	0·03	0·04	0·04	0·05
0·003	3/·036	0·03	0·04	0·05	0·05
0·0045	7/·029	0·03	0·04	0·05	0·05
0·007	7/·036	0·035	0·04	0·05	0·05

TABLE XI

Dimensions of 660 Volt Vulcanised-Rubber-Insulated, Tough-Rubber-Sheathed Cables

Conductors		Thickness of insulation*	Thickness of tough rubber sheath		
Nominal cross-sectional area	Number and diameter (in.) of wires		Single-core*	Twin-core circular†	Three-core circular†
1	2	3	4	5	6
sq. in.	in.	in.	in.	in.	in.
0·0015	1/·044	0·055	0·04	0·05	0·05
0·002	3/·029	0·055	0·04	0·05	0·05
0·003	3/·036	0·055	0·04	0·05	0·05
0·0045	7/·029	0·055	0·04	0·05	0·05
0·007	7/·036	0·06	0·04	0·05	0·05

TABLE XII

Dimensions of Vulcanised-Rubber-Insulated Cables for Communication Circuits

Conductors		Number of pairs of conductors	Thickness of insulation*	Thickness of lead alloy sheath*	Thickness of polychloroprene sheath (H.R. type)*
Nominal cross-sectional area	Number and diameter (in.) of wires				
1	2	3	4	5	6
sq. in.	in.		in.	in.	in.
0·001	1/·036	1	0·03	0·04	0·04
0·001	1/·036	2(Quad)	0·03	0·05	0·05
0·001	1/·036	3	0·03	0·05	0·05
0·001	1/·036	4	0·03	0·05	0·05
0·001	1/·036	7	0·03	0·06	0·06
0·001	1/·036	11	0·03	0·06	0·06
0·001	1/·036	15	0·03	0·075	0·075
0·001	1/·036	19	0·03	0·075	0·075

* The minimum average of measurements made at a number of equidistant points around and along a sample length of cable.

† Measured at the points where the thickness of sheath is at its geometrical minimum.

TABLE XIII

Dimensions of 660 Volt Cables — Paper-Insulated or Varnished-Cambric-Insulated

Conductor		Minimum thickness of insulation		Minimum thickness of lead alloy sheath	
Nominal cross-sectional area	Number and diameter (in.) of wires	D	E	Single-core	Three-core† (belted)
1	2	3	4	5	6
sq. in.	in.	in.	in.	in.	in.
0·007	7/·036	0·07	0·055	0·06	0·06‡
0·0145	7/·052	0·07	0·055	0·06	0·06‡
0·0225	7/·064	0·07	0·055	0·06	0·06§
0·04	19/·052	0·07	0·055	0·06	0·06
0·06	19/·064	0·07	0·055	0·06	0·06
0·1	19/·083	0·07	0·055	0·06	0·06
0·15	37/·072	0·07	0·055	0·06	0·07
0·2	37/·083	0·07	0·055	0·07	0·07
0·25	37/·093	0·08	0·06	0·07	0·08
0·3	37/·103	0·08	0·06	0·07	0·08
0·4	61/·093	0·09	0·07	0·08	0·09
0·5	61/·103	0·09	0·07	0·08	0·10
0·6	91/·093	0·09	0·08	0·09	0·11
0·75	91/·103	0·10	0·09	0·09	0·12
1·0	127/·103	0·10	0·09	0·10	0·13

† Shaped conductors unless otherwise indicated.

‡ Circular conductors.

§ Circular or shaped conductors.

D is the thickness of insulation between conductors in a multicore cable.

E is the thickness of insulation between any one conductor and the sheath in multicore cables or between the conductor and sheath in a single-core cable.

TABLE XIV

Dimensions of 660 Volt Varnished-Cambric-Insulated, Polychloroprene-Sheathed, Braided and Compounded Cables

Conductor		Minimum thickness of insulation		Minimum thickness of polychloroprene sheath	
Nominal cross-sectional area	Number and diameter (in.) of wires	D	E	Single-core	Three-core†
1	2	3	4	5	6
sq. in.	in.	in.	in.	in.	in.
0·007	7/·036	0·07	0·055	0·08	0·08‡
0·0145	7/·052	0·07	0·055	0·08	0·08‡
0·0225	7/·064	0·07	0·055	0·08	0·08§
0·04	19/·052	0·07	0·055	0·08	0·08
0·06	19/·064	0·07	0·055	0·08	0·08
0·1	19/·083	0·07	0·055	0·08	0·08
0·15	37/·072	0·07	0·055	0·08	0·09
0·2	37/·083	0·07	0·055	0·09	0·09
0·25	37/·093	0·08	0·06	0·09	0·10
0·3	37/·103	0·08	0·06	0·09	0·10
0·4	61/·093	0·09	0·07	0·10	0·11
0·5	61/·103	0·09	0·07	0·10	0·12
0·6	91/·093	0·09	0·08	0·11	—
0·75	91/·103	0·10	0·09	0·11	—
1·0	127/·103	0·10	0·09	0·12	—

† Shaped conductors unless otherwise indicated.

‡ Circular conductors.

§ Shaped or circular conductors.

D is the thickness of insulation between conductors is a multicore cable.

E is the thickness of insulation between any one conductor and the sheath in multicore cables or between the conductor and sheath in a single-core cable.

TABLE XV

Dimensions of 3,300 Volt Impregnated-Paper-Insulated or Varnished-Cambric-Insulated Cables

Conductor	D	Minimum thickness of lead-alloy sheath	
Nominal cross-sectional area	Minimum thickness of insulation	Single-core	Three-core (Shaped Conductors)
1	2	3	4
PAPER-INSULATED			
sq. in.	in.	in.	in.
0·0225	0·11	0·06	0·06
0·04	0·11	0·06	0·06
0·06	0·11	0·06	0·06
0·1	0·11	0·07	0·07
0·15	0·11	0·07	0·08
0·2	0·11	0·07	0·08
0·25	0·11	0·07	0·08
0·3	0·11	0·08	0·09
0·4	0·12	0·08	0·10
0·5	0·13	0·09	0·10
0·6	0·14	0·09	—
0·75	0·15	0·10	—
VARNISHED-CAMBRIC-INSULATED			
0·0225	0·13	0·06	0·06
0·04	0·13	0·06	0·06
0·06	0·13	0·06	0·07
0·1	0·13	0·07	0·07
0·15	0·13	0·07	0·08
0·2	0·13	0·07	0·08
0·25	0·13	0·08	0·09
0·3	0·13	0·08	0·09
0·4	0·14	0·08	0·10
0·5	0·14	0·09	0·11
0·6	0·15	0·09	—
0·75	0·17	0·10	—

Note.—D is the thickness of the insulation as follows:—
(1) Single-core cables: Between the conductor and metallic sheath.
(2) Three-core cables: Between the conductors and between any conductor and metallic sheath.

TABLE XVI

Sizes of Armouring Wire and Thickness of Bedding for Single-wire Armouring

Nominal diameter of cable over lead-alloy sheath		Nominal diameter of galvanised steel wire		Nominal thickness of bedding before the armouring is applied	
Above	Up to and including	Rubber insulated cables	Paper or varnished cambric insulated cables	Rubber insulated cables	Paper or varnished cambric insulated cables
1	2	3	4	5	6
in.	in.	in.	in.	in.	in.
—	0·5	0·048	0·064	0·04	0·06
0·5	0·8	0·064	0·080	0·06	0·06
0·8	1·05	0·080	0·080	0·1	0·10
1·05	2·0	0·104	0·104	0·1	0·10
2·0	—	0·128	0·128	0·1	0·10

TABLE XVII

Minimum Insulation Resistance Values for 250 Volt and 660 Volt Vulcanised-Rubber-Insulated Cables

Conductor	Number and diameter (in.) of wires (or equivalent strand in flexible cables)	Insulation resistance for 1,000 yards at 60° F. (15·6°C.)
Nominal cross-sectional area		
1	2	3
sq. in.		megohms.
0·001	1/·036	3,000
0·0015	1/·044	3,000
0·002	3/·029	2,400
0·003	3/·036	2,100
0·003	1/·064	2,100
0·0045	7/·029	2,000
0·007	7/·036	1,800
0·01	7/·044	1,600
0·0145	7/·052	1,500
0·0225	7/·064	1,300
0·03	19/·044	1,200
0·04	19/·052	1,100
0·06	19/·064	1,000
0·1	19/·083	950
0·15	37/·072	850
0·2	37/·083	850
0·3	37/·103	800
0·4	61/·093	750
0·5	61/·103	700
0·75	91/·103	650
0·1	127/·103	600

Note.—In cables having fire-resisting rubber-like insulation (R.N.N. type) the insulation resistance is to be not less than 20% of the above values (*see* M 728).

TABLE XVIII

MAXIMUM SPACING OF CLIPS SECURING LEAD-ALLOY-SHEATHED, VULCANISED-RUBBER-SHEATHED (H.R. TYPE), OR ARMOURED CABLES

Overall diameter of cable	Lead-alloy-sheathed cables and H.R. type cables	Armoured cables
1	2	3
	inches	inches
Under 0·3 inch ...	8	10
0·3 inch and under 0·5 inch	10	12
0·5 inch and under 0·75 inch	12	14
0·75 inch and under 1·25 inches ...	14	16
1·25 inches and above	16	18

TABLE XIX

MAXIMUM SPACINGS OF CLIPS SECURING MINERAL-INSULATED COPPER-SHEATHED CABLES

Overall diameter of cable	Clip spacing in inches	
	Horizontal	Vertical
Under 0·3 inch	12	16
0·3 inch and under 0·5 inch	15	20
0·5 inch and under 1·0 inch	18	24

TABLE XX

APPROXIMATE CURRENT RATING OF FUSE-ELEMENTS COMPOSED OF TINNED COPPER WIRE OR STANDARD ALLOY* WIRE IN SEMI-ENCLOSED FUSES

Current rating	Tinned copper wire		Standard alloy* wire	
	Diameter	SWG	Diameter	SWG
1	2	3	4	5
amps.	in.		in.	
1·8	—	—	0·0164	27
3·0	0·006	38	0·0240	23
5·0	0·0084	35	0·0320	21
8·5	0·0124	30	—	—
10·0	0·0136	29	—	—
15·0	0·020	25	—	—
17·0	0·022	24	—	—
20·0	0·024	23	—	—
24·0	0·028	22	—	—
30·0	0·032	21	—	—
37·0	0·040	19	—	—
46·0	0·048	18	—	—
53·0	0·048	18	—	—
60·0	0·056	17	—	—
64·0	0·056	17	—	—
83·0	0·072	15	—	—
100·0	0·080	14	—	—

NOTE.—The current ratings given refer to the normal maximum current of the circuit and do not refer to the overload at which the fuse will operate.

The values of the currents given are approximately those necessary to comply with Appendix 5 applied to the above fuse-elements used in semi-enclosed fuses. Where fuses are known to conform to this Appendix the size stated by the manufacturer on the case of the fuse should be adhered to in preference to that given in this Table if the fuse is loaded to its full capacity.

* The term "standard alloy" refers to the eutectic tin-lead alloy (63 per cent tin, 37 per cent lead).

TABLE XXI

Standard Sizes of Direct Current and Alternating Current (3-Phase) Motors with Corresponding Approximate Full-Load Currents

(*See* M 611 and M 1325)

Output of motor	Direct-Current Full-Load Current		Three-Phase Alternating-Current Full-Load Current	
	110 Volts	220 Volts	230 Volts	415 Volts
1	2	3	4	5
h.p.	amps.	amps.	amps.	amps.
0·25	3·2	1·6	—	—
0·5	5·7	2·8	2·5	1·2
1·0	10	5·0	3·8	1·9
2·0	18	9·0	6·7	3·4
3·0	26	13	9·5	4·8
4·0	35	17	12	6·4
5·0	42	21	15	7·9
7·5	61	30	22	11·5
10	80	40	29	14·5
12·5	100	50	35	17
15	117	59	42	21
20	155	77	55	28
25	190	95	67	35
30	227	114	77	41
35	264	132	89	48
40	300	150	101	55
45	340	170	113	62
50	375	187	125	69
60	450	225	150	83
70	520	260	175	96
80	595	298	200	110
90	665	333	224	124
100	740	370	244	136
125	924	462	298	168
150	—	550	352	200

TABLE XXII

CALCULATION OF MAXIMUM CURRENT WHICH WILL NORMALLY FLOW IN AN INSTALLATION TO A GROUP OF CARGO-WINCHES OR CRANES (FOR USE IN COMPUTING THE SIZES OF CABLES, SWITCHGEAR, ETC.) (*See* M 615)

Number of winch motors or crane motors supplied by the circuit 1	Current to be provided for 2
Two	100% F.L. of the larger motor + 30% F.L. of the 2nd motor or 65% of the combined F.L. if the motors are of equal size
Three	100% F.L. of the largest motor + 25% F.L. of each of the remaining motors, or 50% of the combined F.L. if the motors are of equal size
Four	100% F.L. of the largest motor + 20% F.L. of each of the remaining motors, or 40% of the combined F.L. if the motors are of equal size
Five	100% F.L. of the largest motor + 20% F.L. of each of the remaining motors, or 36% of the combined F.L. if the motors are of equal size
Six or more	33% of the combined F.L. of the motors

NOTE.—The letters F.L. refer to the full-load current of the motor at its maximum horse-power rating.

TABLE XXIII

TEMPERATURE LIMITS FOR COILS

Insulating material (See appendix 2.) 1	Maximum temperature rise (*See* M 347 and M 1312)					
	Continuously rated shunt coils 2		Intermittently rated shunt coils 3		Series coils 4	
	°F.	°C.	°F.	°C.	°F.	°C.
Class O	72	40	81	45	99	55
Class A (i) Cotton, silk, paper and similar materials when impregnated; also enamel when associated with such materials ...	90	50	99	55	117	65
(ii) Enamelled wire not in association with such materials	126	70	135	75	153	85
Class B and bare coils	180	100	189	105	207	115
Class D	126	70	135	75	153	85

TABLE XXIV

Limits of Maximum Permissible Temperature Rise for Generators and Motors other than Propulsion Machines intended for machinery spaces in Ocean-going Ships and Ships operating in Tropical Waters

Part of machine	Temperature rise ‡					
	Machines other than totally enclosed				Totally enclosed machines	
	Class A material		Class B material		Class A material	Class B material
	By thermometer	By resistance	By thermometer	By resistance	By thermometer	By thermometer
1. Alternating current windings of stators or rotors	63° F. (35° C.)	72° F. (40° C.)	81° F. (45° C.)	108° F. (60° C.)	81° F. (45° C.)	108° F. (60° C.)
2. Field windings stationary or rotating (other than 3, 4 and 5 below) ...	63° F. (35° C.)	81° F.† (45° C.)	81° F. (45° C.)	99° F.† (55° C.)	81° F. (45° C.)	108° F. (60° C.)
3. Exciter field windings	63° F. (35° C.)	*	81° F. (45° C.)	*	81° F. (45° C.)	108° F. (60° C.)
4. Low resistance field windings of more than one layer or compensating windings	72° F. (40° C.)	*	90° F. (50° C.)	*		
5. Single-layer field windings with exposed surface	81° F. (45° C.)	81° F. (45° C.)	108° F. (60° C.)	108° F. (60° C.)	81° F. (45° C.)	144° F. (80° C.)
6. Short-circuited windings insulated ...	81° F. (45° C.)	*	108° F. (60° C.)	*		
7. Windings of armatures having commutators	63° F. (35° C.)	*	81° F. (45° C.)	*	81° F. (45° C.)	108° F. (60° C.)
8. Commutators	72° F. (40° C.)				90° F. (50° C.)	
9. Slip rings (open)	72° F. (40° C.)					
10. Slip rings (enclosed)	90° F. (50° C.)				90° F. (50° C.)	
11. Uninsulated parts, including cores not in contact with insulated windings ...	The temperature rise is in no case to reach such a value that there is risk of injury to any insulating material on adjacent parts.					

* This method of measurement is not recognised in these cases.

† This method is not recognised in the case of direct-current machines.

‡ Based on a temperature of cooling air not exceeding 113° F. (45° C.). *See* M 207 and M 1205.

TABLE XXV

Limits of Maximum Permissible Temperature Rise for Generators and Motors, other than Propulsion Machines

(*a*) Not situated in the machinery spaces of ocean-going ships or of ships operating in tropical waters.
(*b*) Pipe-ventilated or water-cooled (*see* M 203 to M 205 and M 1201 to M 1203).
(*c*) For coasters, ferries and harbour craft operating solely outside the tropical belt.

Part of machine	Temperature rise ‡					
	Machines other than totally enclosed				Totally enclosed machines	
	Class A material		Class B material		Class A material	Class B material
	By thermometer	By resistance	By thermometer	By resistance	By thermometer	By thermometer
1. Alternating current windings of stators or rotors	72° F. (40° C.)	81° F. (45° C.)	90° F. (50° C.)	117° F. (65° C.)	90° F. (50° C.)	117° F. (65° C.)
2. Field windings stationary or rotating (other than 3, 4 and 5 below) ...	72° F. (40° C.)	90° F.† (50° C.)	90° F. (50° C.)	108° F.† (60° C.)	90° F. (50° C.)	117° F. (65° C.)
3. Exciter field windings	72° F. (40° C.)	*	90° F. (50° C.)	*	90° F. (50° C.)	117° F. (65° C.)
4. Low resistance field windings of more than one layer or compensating windings	81° F. (45° C.)	*	99° F. (55° C.)	*		
5. Single-layer field windings with exposed surface	90° F. (50° C.)	90° F. (50° C.)	117° F. (65° C.)	117° F. (65° C.)	90° F. (50° C.)	153° F. (85° C.)
6. Short-circuited windings insulated ...	90° F. (50° C.)	*	117° F. (65° C.)	*		
7. Windings of armatures having commutators	72° F. (40° C.)	*	90° F. (50° C.)	*	90° F. (50° C.)	117° F. (65° C.)
8. Commutators	81° F. (45° C.)				99° F. (55° C.)	
9. Slip rings (open)	81° F. (45° C.)					
10. Slip rings (enclosed)	99° F. (55° C.)				99° F. (55° C.)	
11. Uninsulated parts, including cores not in contact with insulated windings ...	The temperature rise is in no case to reach such a value that there is risk of injury to any insulating material on adjacent parts.					

* This method of measurement is not recognised in these cases.

† This method is not recognised in the case of direct-current machines.

‡ Based on a temperature of cooling air not exceeding 104° F. (40° C.). *See* M 207 and M 1205.

TABLE XXVI

Dimensions of 250 Volt Mineral-insulated Copper-sheathed Cables

Conductor		Resistance per 1,000 yds. at 60° F.		Nominal thickness of insulation		Nominal diameter over sheath		
Nominal cross-sectional area	Nominal diameter	Nominal	Maximum allowable	Single-core	Twin- and multi-core	Single-Core	Twin-core	Three-Core
1	2	3	4	5	6	7	8	9
sq. in.	in.	ohms	ohms	in.	in.	in.	in.	in.
0·0015	0·044	16·0	17·0	0·034	0·036	0·161	0·238	0·257
0·002	0·051	12·0	12·72	0·036	0·04	0·169	0·272	0·290
0·003	0·062	8·0	8·5	0·038	—	0·180	—	—
0·0045	0·076	5·33	5·65	0·039	—	0·196	—	—
0·007	0·094	3·43	3·64	0·041	—	0·228	—	—

Note.—The nominal diameters over sheath correspond to British Standard drill sizes for clearance holes and the cable will generally be between 0·002 in. and 0·006 in. less than the figures given so that it will be a good fit in glands, etc., drilled to these sizes.

TABLE XXVII

Dimensions of 660 Volt Mineral-insulated Copper-sheathed Cables

Conductor		Resistance per 1,000 yds. at 60°F.		Nominal thickness of insulation	Nominal diameter over sheath		
Nominal cross-sectional area	Nominal diameter	Nominal	Maximum allowable		Single-core	Twin-core	Three-core
1	2	3	4	5	6	7	8
sq. in.	in.	ohms	ohms	in.	in.	in.	in.
0·0015	0·044	16	17	0·06	0·218	0·328	0·344
0·002	0·051	12	12·72	0·06	0·228	0·344	0·368
0·003	0·062	8	8·5	0·06	0·238	0·368	0·386
0·0045	0·076	5·33	5·65	0·06	0·250	0·397	0·422
0·007	0·094	3·43	3·64	0·06	0·272	0·437	0·453
0·01	0·113	2·4	2·54	0·06	0·290	0·469	0·516
0·0145	0·136	1·66	1·76	0·06	0·323	0·531	0·562
0·0225	0·169	1·07	1·13	0·06	0·349	0·594	0·641
0·03	0·196	0·8	0·85	0·06	0·386	0·656	0·720
0·04	0·226	0·6	0·64	0·06	0·422	—	—
0·06	0·276	0·4	0·42	0·06	0·484	—	—
0·1	0·356	0·24	0·255	0·06	0·578	—	—
0·15	0·436	0·16	0·17	0·06	0·672	—	—
0·2	0·506	0·12	0·127	0·06	0·75	—	—

Note.—The nominal diameters over sheath correspond to British Standard drill sizes for clearance holes and the cable will generally be between 0·002 in. and 0·006 in. less than the figures given so that it will be a good fit in glands, etc., drilled to these sizes.

TABLE XXVIII

Current Ratings for Mineral-insulated Copper-sheathed Cables

Conductor	Single-core Cables		Twin-core Cables		3-or 4-core Cables	
Nominal cross-sectional area	Current rating*	Approximate length of run† for 1-volt drop with current as in Col. 2 A.C or D.C.	Current rating*	Approximate length of run† for 1-volt drop with current as in Col. 4 A.C. or D.C	Current rating*	Approximate length of run† for 1-volt drop for balanced 3-phase A.C. current as in Col. 6
1	2	3	4	5	6	7
sq. in.	amps.	feet	amps.	feet	amps.	feet
0·0015	5	17	5	17	5	20
0·002	10	11	10	11	10	13
0·003	15	11	15	11	15	13
0·0045	20	12	20	12	20	14
0·007	55	7	45	8	35	13
0·01	70	8	55	10	45	14
0·0145	90	9	70	11	55	16
0·0225	110	11	85	14	70	20
0·03	130	12	100	16	85	22
0·04	150	14	—	—	—	—
0·06	200	15	—	—	—	—
0·1	260	19	—	—	—	—
0·15	330	22	—	—	—	—
0·2	400	22	—	—	—	—

* The current ratings are subject to the maximum permissible voltage drop not being exceeded.

† The "length of run" is the point-to-point distance measured along the route taken by the cables.

TABLE XXIX

Miscellaneous Rubber-insulated Cables

THICKNESS OF LEAD SHEATH

Calculated diameter under lead sheath		Radial thickness of sheath
above	up to and including	
1	2	3
in.	in.	in.
—	0·290	0·040
0·290	0·365	0·050
0·365	0·455	0·060
0·455	0·660	0·070
0·660	0·780	0·080
0·780	1·110	0·090
1·110	1·5	0·10
1·5	1·7	0·11
1·7	1·9	0·12
1·9	2·1	0·13
2·1	2·5	0·14
2·5	3·0	0·15

NOTE.—This table applies only to miscellaneous cables not included in any table of dimensions in these rules.

APPENDIX 1

BUSBARS AND CONNECTIONS

1. **Material.**—The copper used is to have a conductivity for annealed copper not less than 99·25 per cent, and for medium hard and hard copper not less than 95 per cent of the International Standard for standard annealed copper.

2. **Joints.**—All joints between copper conductors are to be made after dip-tinning or coating with petroleum jelly, or have equally effective treatment for preventing deterioration of the joint.

All joints, whether soldered or not, are to have the parts mechanically secured together.

3. **Limits of Temperature Rise.**—The following temperature limitations, measured by thermometer or thermocouple, are to apply to bare conductors in contact with air, when carrying their full rated current.

(*a*) Conductors rated 2,000 amps. and below, maximum temperature 158° F. (70° C.).
Maximum temperature rise 72° F. (40° C.).

(*b*) Conductors rated above 2,000 amps., maximum temperature 176° F. (80° C.).
Maximum temperature rise 90° F. (50° C.).

4. **Thermal Expansion.**—Where necessary, provision is to be made to allow for expansion and contraction due to temperature variations.

5. **Clearance Distances.**—The clearance distances specified below apply only to busbars having no insulating covering other than the surrounding air, compound or oil.

Max. Rated Voltage between Phases or Poles	Minimum Clearance to Earth		Minimum Clearance between Phases or Poles	
	In Air	In Oil or Compound	In Air	In Oil or Compound
	inches	inches	inches	inches
660	$\frac{5}{8}$	—	$\frac{3}{4}$	—
2,200	$1\frac{1}{2}$	—	$1\frac{1}{2}$	—
3,300	2	$\frac{1}{2}$	2	$\frac{3}{4}$
6,600	$2\frac{1}{2}$	$\frac{3}{4}$	$3\frac{1}{2}$	1

IMPORTANT NOTE.—The above figures do not apply to creepage distance along the surface of insulators or of insulating bases.

6. **Mechanical Strength.**—The busbars and connections are to be so proportioned and supported as to be capable of safely withstanding the maximum mechanical stresses to which they may be subjected by the initial value of the short circuit current.

APPENDIX 2

INSULATING MATERIALS

1. **Classification of Materials**

(*a*) For the purpose of these Rules the following International designations will apply.

Class O. Cotton, silk, paper and similar organic materials when neither impregnated nor immersed in oil.

Class A. Cotton, silk, paper and similar organic materials when impregnated or immersed in oil, also the substance known as enamel applied to enamelled wire.

NOTE.—Impregnated cotton, paper or silk (also compound treated insulation).—An insulation is considered to be impregnated when a suitable substance replaces the air between its fibres, even if this substance does not completely fill the spaces between the insulated conductors. The impregnating substance, in order to be considered suitable, must have good insulating properties, must entirely cover the fibres and render them adherent to each other and to the conductor, must not produce interstices within itself as a consequence of evaporation of the solvent or through any other cause, must not flow at the temperature limit specified, must not unduly deteriorate under prolonged action of heat.

Class B. Mica and asbestos and similar inorganic materials in built up form combined with binding cement. If Class A material is used in small quantities for structural purposes only, in conjunction with Class B insulation, the combined materials may be considered as Class B, provided the electrical and mechanical properties of the insulated winding are not impaired by the application of the temperature permitted for Class B material. (The word "impair" is here used in the sense of causing any change which could disqualify the insulating material for continuous service.)

Class C. Mica, without binding cement, porcelain, glass, quartz and other similar materials.

Class D. Coils insulated with synthetic resin impregnation.

(*b*) INSULATION MADE UP OF DIFFERENT MATERIALS. When the insulation is made up of different materials (except in those cases defined under Class B) the temperature rise attained by each material is not to exceed the limit permitted for that material.

Examples

(i) When the different insulating materials are used on various parts of one winding (for instance, in the slot and for the end windings) the limit of temperature rise applicable to any part of the winding is that set for the insulation used on the part.

(ii) When the insulation on any part consists of superposed layers of insulating materials falling in different classes (for instance, superposed layers of Class A and Class B material) the two following cases arise.

If it is possible to measure the temperatures attained by the various layers, each of the materials is entitled to the temperature rise which is assigned to it.

If it is not possible to measure the temperatures attained by the various layers, the temperature rise applicable to the part of the winding under consideration is to be taken as that for the insulating material with the lowest limit.

2. Synthetic Insulating Boards, Tubes, etc., used for terminal boards and for mounting the live metal parts of switchgear and control gear.—Material used for insulation slabs for switchboards, section boards, distribution fuse boards, terminal boards of apparatus and machines and similar applications is to be suitable for the purpose intended and is to be submitted for approval. Results of tests indicating the suitability of the material are to be submitted, the nature of which will depend on the application proposed. The materials are to be of first-class quality and, where relevant approved National Standards exist, they are to comply with such standards. In general the tests should indicate the properties of the materials in relation to the following:—

(*a*) Insulation Properties

(i) Surface insulation resistance

(ii) Surface breakdown

(iii) Dielectric strength

These tests should preferably be carried out in an atmosphere of controlled temperature and humidity and, in certain cases, after immersing the sample in water.

(*b*) Water Absorption

(*c*) Mechanical Properties

(*d*) Heat Resistance

(i) Mechanical strength when heated within the limits of the working temperatures.

(ii) Softening or tendency to flow or warp under combined heat and mechanical stress.

(*e*) Inflammability.—Self-extinguishing, non-inflammable or non-ignitable properties when heated by a Bunsen flame.

APPENDIX 3

MOTORS AND GENERATORS FOR POWER AND LIGHTING SERVICES AND EXCITERS, BALANCERS AND BOOSTERS IN CONJUNCTION WITH ELECTRICAL PROPELLING MACHINERY

1. Overloads in Current and Torque.—Generators and motors are to be capable of carrying without injury, the following overloads in current and torque respectively after having attained the temperature rise corresponding to their rated load, the voltage and frequency being maintained at their rated values. Sustained overloads are not recognised for the following types of machines:—

(*a*) Totally enclosed.

(*b*) Short time rated.

Motors with continuous rating are to withstand the following overloads in torque.

(i) Sustained overloads:—

Sizes 10 b.h.p. and upwards per 1,000 rpm	25 per cent for two hours.
Sizes 4 b.h.p. up to 10 b.h.p. per 1,000 rpm	25 per cent for one half-hour.
Sizes below 4 b.h.p. per 1,000 rpm ...	25 per cent for 15 minutes.

(ii) Momentary overloads:—

All sizes	50 per cent for one minute.
D.C. motors up to 150 b.h.p. per 1,000 rpm	100 per cent for 15 seconds.
A.C. motors, all sizes	100 per cent for 15 seconds.

GENERATORS with continuous rating are to withstand the following overloads in current.

(i) Sustained overloads:—

Sizes 7½ kW or kVA and upwards per 1,000 rpm	25 per cent for two hours.
Sizes 3 to 7½ kW or kVA per 1,000 rpm	25 per cent for one half-hour.
Sizes below 3 kW or kVA per 1,000 rpm	25 per cent for 15 minutes.

(ii) Momentary overloads:—

All sizes	50 per cent for one minute.

NOTE.—The b.h.p. or kVA per 1,000 rpm = $\frac{\text{Rated b.h.p. or kVA (or kW if D.C.)} \quad 1000}{\text{Rated Speed.}}$

2. **Method of Temperature Measurement.**—The method to be used in any particular case is stated in the following sub-paragraphs (*a*), (*b*) and (*c*).

(*a*) EMBEDDED TEMPERATURE DETECTORS (E.T.D.). This method is to be employed for the slot position of stator windings of the following types of machine:—

(i) Machines having a rated output of 5,000 kVA or more.

(ii) Machines having an axial core length of one metre or over.

(*b*) THERMOMETER METHOD. Mercury or alcohol bulb thermometers are to be employed, the latter being used where the magnetic field in the vicinity of the thermometers alternates or rotates. The temperatures are to be measured by thermometers applied to the hottest accessible surfaces of the stationary parts of the machine during the test period and other thermometers to the accessible surfaces of the rotating parts as soon as the machine is stopped after the test. The bulb of the thermometer, except at the point of contact, is to be covered with a pad of felt, cotton wool or other non-conducting material ⅛ inch thick, extending at least ¾ inch in every other direction from the bulb and pressed into contact to prevent the loss of heat by radiation and convection from the bulb.

(*c*) RESISTANCE METHOD. The measurement of temperature rise by increase of resistance is applicable to all field windings (except stationary low resistance field windings and exciter field windings) and to stator windings not requiring the use of E.T.D. It is not to be used for the alternating current windings of machines requiring more than 5 minutes to come to rest. Resistance measurements are to be made before and at the conclusion of the temperature test.

(*d*) TEMPERATURE OF COOLING AIR. The temperature of the cooling air for open type machines is to be measured by means of several thermometers at different points around and half way up the machine situated at distances of three to six feet away from it.

3. **Duration of Temperature Test.**—The temperature test for a machine having a continuous rating is to be of such duration that sufficient evidence is available to show that the temperature rise would not exceed the permissible limits were the test prolonged until a final steady temperature was reached. It is in no case necessary to prolong the test after a steady temperature rise has been reached. The duration of the temperature test for a machine having a short time rating is to be the time required for the rating.

4. **Temperature for a Machine having more than one Rating.**—When a machine has more than one rating, the temperature test is to be carried out at that rating which produces the greatest temperature rise. In cases where this cannot be determined beforehand, the machine is to be tested separately under each of its ratings.

5. **Commutation.**—A D.C. machine is to work with fixed brush setting from no load to the momentary excess current or torque specified and is to work sparklessly and without injury to the commutator or brushes from no load to the rated load and without injurious sparking or injury to the commutator or brushes up to the momentary excess current or torque specified. The commutation test is to be applied at the conclusion of the temperature test.

6. **Regulation.**—The voltage regulation tests on generators and speed/load characteristics of motors are to be carried out at the conclusion of the temperature tests.

7. **High Voltage (Dielectric) Tests.**—The high voltage tests, in accordance with Table A overleaf, are to be applied only to new and completed machines in normal working condition with all parts in place, at the makers' works, preferably at the conclusion of the temperature test. It is to be applied between the terminals and the frame with the core connected to the windings not under test. The test is to be made with alternating voltage of any convenient frequency between 25 and 100 cycles per second, of approximately sine-wave form. The test is to be commenced at a voltage of about one-third the test voltage and is to be increased to the full test voltage as rapidly as is consistent with its value being indicated by the measuring instrument. The full test

voltage is then to be maintained for one minute and then reduced to one-third of its full value before switching off.

TABLE A
HIGH VOLTAGE TESTS

ITEM	MACHINE OR PART	TEST VOLTAGE
1	Machines under 3 b.h.p./kW/kVA per 1000 rpm.	1,000 V + twice the rated voltage.
2	Machines 3 b.h.p. / kW / kVA and above per 1000 rpm.	1,000 V + twice the rated voltage—minimum 2000 V
3	Field windings for synchronous generators when the excitation voltage does not exceed 750 V	10 times the excitation voltage—minimum 2,000 V, maximum 3,500 V
4	Field windings for synchronous motors :	
	(*a*) when intended to be started up with the field windings short-circuited or connected across the exciter armature.	10 times the excitation voltage—minimum 2,000 V, maximum 3,500 V
	(*b*) when intended to be started up with the field windings separated by a field dividing switch.	5,000 V
	(*c*) when intended to be started up with the fields on open circuit and without a field-dividing switch.	5,000 V when the excitation voltage is less than 275 V, 8,000 V when the excitation voltage is equal to or exceeds 275 V
5	Field windings for synchronous motors when intended to be started up with A.C. windings idle.	As for 4(*a*).
6	Exciter	Not less than that applied to the field windings of the machine to which it is connected, except when used with a synchronous machine intended to be started up from the alternating current side, in which case the test will be as given in Item 4 (*a*).
7	Secondary (rotor) windings of induction motors not permanently short-circuited.	For non-reversing motors :— 1,000 V + twice the maximum voltage induced between slip rings. For reversing motors :— 1,000 V + four times the maximum voltage induced between the slip rings at standstill with full primary voltage applied to stator windings.

8. **Supplementary High Voltage (Dielectric) Tests.**—When for any reason it is desired to make additional high voltage tests on a machine which has already passed its tests in accordance with paragraph 7 and when installed on site such additional high voltage tests are to be made in accordance with the requirements of paragraph 7, except that the voltage is to be 75 per cent of that specified above. Before the high voltage test is applied, the windings are to be cleaned and, if necessary, dried out.

9. **Insulation Resistance.**—The insulation resistance in megohms when the high voltage test is applied is not to be less than :—

$$\frac{3 \times \text{rated volts}}{1{,}000 + \text{rated output in kVA or b.h.p.}}$$

The insulation resistance is to be measured with a D.C. voltage of about 500, preferably at the conclusion of the temperature test of the machine.

10. **Abbreviated Tests.**—In the case of duplicate machines up to 50 kW b.h.p. per 1,000 rpm type tests of temperature rise, excess current and torque and commutation taken on a machine identical in rating and in all other essential details may be accepted in conjunction with abbreviated tests on each machine. For the abbreviated tests each machine is to be run and is to be found electrically and mechanically sound and in working order in all particulars, and is to have a high voltage (dielectric) test and insulation resistance test.

11. Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces are to be tested in accordance with the following :—

The Surveyor will witness a type test on the first motor of each size and type and works test certificates are to be supplied for the remainder. This type test may also be accepted for repeat orders of motors identical in all essential respects provided cross references are given in the works test certificates. Type tests need not be carried out for motors of the same frame size as one previously tested for higher output.

Where motors are mounted in the air stream but are tested under still air conditions, generally two conditions may arise.

(i) The motor may be open at one or both ends when tested but totally enclosed when mounted in the air stream. In such cases a type test should be carried out under working conditions, i.e., in the trunking with the fan and fairings in place, or, alternatively, calculations furnished to verify that the Rules for temperature rise are complied with.

(ii) The motor may be totally enclosed but with streamlined fairings. These may be accepted if, when tested in still air, the temperature rises are within the requirements of the Rules for totally enclosed motors, but if they are outside these requirements the procedure in (i) above will be followed.

12. **Water-cooled Machines.**—For water-cooled machines the temperature rise is to be measured in relation to the temperature of the cooling water, measured at the inlet.

APPENDIX 4

MAIN ALTERNATORS, MOTORS AND DIRECT-CURRENT GENERATORS FOR ELECTRIC PROPULSION PURPOSES (Continuous Maximum Rating)

1. **General.**—Generators and motors for electric propulsion purposes are to conform in all respects to the requirements of Appendix 3, except as modified hereunder.

2. **Rating.**—The continuous maximum rating is the load which can be carried on test for an unlimited period without exceeding the specified limits of temperature rise.

TABLE B

LIMITS OF PERMISSIBLE TEMPERATURE RISE

Item	Part of Machine	Class A Material		Class B Material			
		By thermometer method 1	By resistance method 2	By thermometer method 3	By resistance method 4	By E.T.D. (a) (see below) 5	By E.T.D. (b) note 6
1	A.C. windings of stators or rotors.	81°F. (45°C.)	90°F. (50°C.)	99°F. (55°C.)	126°F. (70°C.)	126°F. (70°C.)	108°F. (60°C.)
2	Field windings (other than 3, 4 & 5).	*	90°F. (50°C.)	*	126°F. (70°C.)	*	*
3	Low resistance field windings of more than one layer, or compensating windings.	90°F (50°C.)	*	108°F. (60°C.)	*	*	*
4	Single layer field windings with exposed bare copper surface.	99°F. (55°C.)	99°F. (55°C.)	135°F. (75°C.)	135°F. (75°C.)	*	*
5	Rotating field windings of high speed turbine driven alternators.	*	90°F. (50°C.)	*	144°F. (80°C.)	*	*
6	Short circuit windings insulated.	99°F. (55°C.)	*	135°F. (75°C.)	*	*	*
7	Windings of armatures having commutators.	81°F. (45°C.)	*	99°F. (55°C.)	*	*	*
8	Short circuited windings un-insulated.	The temperature rise of these parts is in no case to reach such a value that there is a risk of injury to any insulating or other material on adjacent parts.					
9	Iron core and other parts not in contact with windings						
10	Iron core and other parts in contact with windings.	The same limits of temperature rise as permitted for adjacent parts as given in Cols. 1 and 3 (or 2 and 4 in the case of Item 2).					
11	Commutators ... Slip rings (open) ... Slip rings (enclosed)	81° F. (45° C.). 81° F. (45° C.). 90° F. (50° C.).					

(a) Between coils in one slot.
(b) Between outside of coil and bottom of slot.
* This method of measurement is not recognised in these cases.

3. **Limits of Temperature Rise.**—The limits of temperature rise given in Table B apply only to machines for electric propulsion purposes, having a maximum continuous rating, provided no sustained overloads are thrown upon it under normal service conditions.

4. **Excess Current and Torque.**—(*a*) Generators are to be capable of withstanding on test for 15 seconds a current in amperes 50 per cent in excess of their rated current, the voltage being maintained as near the rated output as possible consistent with the maximum capacity of the prime mover. The exact value of the voltage is not important.

(*b*) Direct current motors are to be capable of withstanding on test for 15 seconds a torque 50 per cent in excess of that corresponding to their rating, the voltage being maintained at rated value.

(*c*) Synchronous motors are to be capable of withstanding for 15 seconds without dropping out of synchronism a torque 50 per cent in excess of the torque corresponding to their rating, the voltage and frequency of the A.C. system with which they are synchronised being maintained at their rated values and the excitation of the motor being maintained at the value required to meet the specified conditions at rated load.

(*d*) Induction motors are to be capable of withstanding for 15 seconds without stalling a torque 50 per cent in excess of the torque corresponding to their rating, the voltage and frequency being maintained at their rated values.

5. **Short Circuit Test on Alternators.**—Alternators are to be capable of withstanding a momentary short circuit at the terminals of the machine applied when generating normal full rated voltage.

6. **Tests.**—All machines are to be tested at the manufacturers' works in the presence of the Surveyors. Where the machines are too large to carry out a temperature test at full load, proposals for equivalent tests are to be submitted for consideration. The high voltage and insulation tests and methods of temperature measurement are to be in accordance with Appendix 3.

Exciters and machines connected therewith, irrespective of rating, are also to be tested in the presence of the Surveyors.

APPENDIX 5
FUSES

1. **Current Rating.**—The current rating of a fuse is the current which the fuse will carry continuously without deterioration, and at which the specified temperature rise at any part does not exceed that specified in paragraph 5 of this Appendix.

The term "fuse" includes all parts of the device, i.e., the fuse-element, contacts, carrier, base and terminals.

2. **Category of Duty.**—Approved fuses will be assigned for convenient reference a category of duty derived from the breaking capacity tests, and a fuse is not to be installed in any circuit having a prospective short circuit current in excess of that for which the fuse is assigned. The prospective short circuit current is the current which would flow through a short circuit applied to the supply terminals of the fuses under normal working conditions. The following categories of duty will be recognised as standard :—

Category of Duty	Maximum Prospective Current of Test Circuit (amperes)
1	1,000
2	4,000
3	16,500
4	33,000

Fuses having a rated breaking capacity intermediate between these values will be assigned to the next lower category.

Fuses connected to the busbars of main switchboards, i.e., those busbars to which the generators are connected, are not to be used with generators having a greater total output under working conditions than that corresponding to the category of duty as shown in the following schedule :—

Category of Duty of Fuse	Maximum Total kW Capacity of Generators, under working conditions		
	100–125 volts D.C.	200–250 volts D.C	3-phase 440 volts A.C.
1	60	100	300
2	250	400	1,000
3	1,200	2,000	5,000
4	over 1,200	over 2,000	over 5,000

The fuses installed on section boards and distribution fuse boards will generally be of the same category of duty as on the main switchboard, but in special cases they may be of a lower category based on the prospective short circuit current at the position at which they are connected.

3. **General Construction.**—The contacts are to be so constructed and of such material that sufficient pressure is maintained under ordinary service conditions after repeated engagement and disengagement and when left untouched for long periods. Fuse links are to be such that overheating, arcing and scattering of hot metal or other substances is obviated. All non-metallic parts are to be constructed of non-ignitable, non-hygroscopic insulating material, provided that cartridges with their attached labels need not necessarily be non-ignitable, and that tubular linings, if any, enclosing fuse elements, linings of containing cases or covers, if any, and fillers of cartridges, need not of necessity be non-hygroscopic. The requirements of M 362 to M 369 are to be complied with.

4. **Approval.**—In order to secure approval of fuses a report, preferably by an independent authority, is to be submitted for consideration, giving details of performance, fusing characteristics, temperature and insulation tests, and accompanied by outline drawings. The drawings should indicate the general arrangement and leading dimensions, including dimensions of contacts and terminals. Samples should not be submitted unless specially requested.

Fuses will be approved for standard direct current voltages up to 250, and alternating current voltages up to 440, and a list of approved fuses will be issued.

5. **Temperature Rise.**—Fuses are to be tested in surroundings free from external draughts and in the containing cases, if any, in which they may be used in service and in the position in which they will normally be mounted. The maximum temperature rises of contacts and fixed terminals (or sweating sockets when used), at the top of fuses if mounted vertically, and of the connections, are to be measured by thermo-couples attached by means of low-melting-point alloy, or by some equally effective means of attachment.

The points at which the temperature rises are measured are to be :—

(*a*) For contacts: the point at which the maximum temperature rise may be expected to occur.

(*b*) For fixed terminals, or, when used, sweating sockets: the accessible point closest to the external connection.

(*c*) For connections: a point 1 foot along the conductor from the corresponding terminal or sweating socket.

Thermo-couples of copper-constantan attached by a low-melting-point alloy of equal parts of lead, tin, and bismuth are considered suitable.

After the fuses have carried their maximum rated current continuously for sufficient time to allow their temperatures to become steady the temperature rise of the fuse contacts is not to exceed 99° F. (55° C.), and of the fixed terminals (or sweating sockets when used) is not to exceed 83° F. (46° C.).

The conductors connected to fuses on test are to be of copper of uniform cross-section not greater than that shown below and are to be so disposed and covered, and/or lagged, that the temperature rise at a point up to 1 ft. from the fixed terminal or sweating socket is not less than 85 per cent of the actual temperature rise on test of that terminal or sweating socket (when used).

Fuse rating	Maximum size of Conductor
amps.	sq. inches
5	0·002
15	0·0045
30	0·007
60	0·0145
100	0·03
150	0·06
200	0·1

The covering and/or lagging is to be so applied that it is at least as thick over the portion of the connection within 1 foot of the terminal as it is over any other portion.

6. **Performance (Breaking Capacity).**—Fuses are to be type-tested to ensure the satisfactory opening of the circuit when wired for their maximum current rating under conditions capable of producing the requisite prospective current according to the category of duty.

Fuses that are to be used in unlined metal cases are to be tested in bare metal cases having clearances from the fuse-parts not greater than the minimum clearances to be used in service. Fuses that are to be used in service without cases, or only in cases of insulating material, are to be tested in woven wire cloth enclosures having suitable clearances from the fuse-parts.

During the tests, metal cases and woven wire cloth wrappings are to be connected to earth through fine-wire fuses, wired with copper wire not greater than 0·0048 in. in diameter with a break not less than 3 in.

Fuses are to be tested for duty by testing single fuses in a single-phase A.C. circuit or in a D.C. circuit at not less than the voltage rating of the fuse. When tested in an A.C. circuit, the circuit is to be made at a rising voltage of 50 per cent of the peak value, with a tolerance of plus or minus 15 per cent of the peak value.

One pole of the test circuit is to be connected to earth, and in D.C. tests this is to be the negative pole. One terminal of the fuse to be tested is to be connected direct to that pole of the supply circuit which is not earthed.

The source of energy for the tests is to be capable of giving the required prospective currents and is to produce initially a recovery voltage not less than 90 per cent and not more than 100 per cent of the voltage rating of the fuse in A.C. tests and not less than 100 per cent and not more than 110 per cent of the voltage rating of the fuse in D.C. tests. If necessary, the test voltage may be increased initially above the voltage rating of the fuse in order to ensure that the recovery voltage will have the required value.

The frequency of supply for A.C. tests is to be 50 cycles per second plus or minus 25 per cent.

The impedance of an A.C. test circuit, including, if required, a resistor and a reactor in circuit with the fuse, is to be appropriate to the required prospective current at a power factor in accordance with the table below.

Category of Duty	Maximum Prospective Current of test circuit (amperes)	Power Factor (Lagging) not greater than	Time constant (L/R) not less than
1	1,000	0·6	0·0030
2	4,000	0·4	0·0040
3	16,500	0·3	0·0100
4	33,000	0·3	0·0150

The resistance of a D.C. test circuit, including, if required, a resistance in circuit with the fuse, is to be appropriate to the required prospective current, and the resistance and inductance of the circuit is to be such that the circuit has a time constant in accordance with the above table.

The recovery voltage is to be maintained at not less than 90 per cent of the voltage rating of the fuse in A.C. tests and not less than 100 per cent in D.C. tests for not less than 30 seconds immediately after the opening of the circuit by the fuse in order to prove that the fuse will withstand indefinitely continued application of its voltage rating.

The insulation-resistance between the terminals of the fuse-link is to be measured at the conclusion of the test.

Not less than three tests are to be made using the same fuse throughout, without the renewal of any parts other than fuse-elements and asbestos tubes or the like, if any, of semi-enclosed fuses, or fuse-links of cartridge-fuses.

Fuses are deemed not to comply with the requirements if, during one of these tests, any of the following failures occur :—

(*a*) Melting of the fine-wire fuse, indicating arcing to the metal case.

(*b*) Ignition of the fuses or ignition or damage of neighbouring apparatus, excluding any paper labels or the like used as indicating devices on the fuses.

(*c*) Mechanical damage sufficient to render any of the following parts unserviceable without repairs : fuse contacts, fuse carriers, fixed contacts, bases, cases or any other parts not intended to become unserviceable on the melting of the fuse-elements.

(*d*) In cartridge fuses, violent bursting of cartridges.

(*e*) Reduction of the insulation resistance between the terminals of the fuse-link to less than 100,000 ohms when measured at 500 volts within 3 minutes after the conclusion of the test.

(*f*) A maximum arc-voltage greater than 2·5 kV.

The test certificate should state whether the test has been carried out with A.C. or D.C.

7. **Insulation Resistance.**—The insulation resistance measured

(*a*) between the fixed terminals, and

(*b*) between live parts and the containing metal case, if any, with all other parts in position except the fuse-element, is to be not less than 50 megohms.

8. **Marking.**—Fuse carriers intended for use with semi-enclosed fuse-links, or alternatively the containing cases, if any, of semi-enclosed fuses, and cartridges are to be indelibly marked with the maximum current rating (*see* paragraph 1) for which the fuses of which they form parts are suitable.

9. **British Standards.**—Fuses complying with the requirements of B.S. 88 will be accepted as meeting the requirements of this Appendix, provided paragraphs 4 and 5 are complied with.

APPENDIX 6

FLAMEPROOF ENCLOSURE

1. Where apparatus is required to be of the flameproof type and apparatus of suitable type is obtainable which has been type-tested and approved by a competent independent Testing Authority, such as, in the United Kingdom, the Ministry of Fuel and Power, for gases and vapours in Group II*, such apparatus only is to be used. Where such apparatus is not obtainable, the flameproof enclosure is to comply with the following requirements.

2. **Definition.**—A flameproof enclosure for electrical apparatus is one which will withstand, without injury, any explosion of the prescribed inflammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognised overloads, if any, associated therewith) and will prevent the transmission of flame such as will ignite the inflammable gas which may be present in the surrounding atmosphere.

NOTE.—Short of permanent hermetic sealing, which is generally impracticable, it must be assumed that any external explosive atmosphere may find its way within the enclosure and, moreover, that an ignitable atmosphere may be produced internally by the decomposition of oils, varnishes, rubber, etc. The term "gas-tight," therefore, has been deliberately discarded in favour of the term "flameproof."

3. **Construction.**—Where a certificate has been obtained from a recognised independent Testing Authority it will be sufficient to furnish a copy of the relevant certificate when required, provided there is no departure from the design so tested and approved.

* *See* Ministry of Fuel and Power Testing Memorandum No. 4.

Where suitable apparatus approved by a recognised competent Testing Authority as required by paragraph 1 is not obtainable the apparatus fitted is to comply with the structural requirements of B.S. 229–1946 for gases and vapours in Group II, and full details of the construction are to be submitted for consideration before the work is commenced.

APPENDIX 7

TINNING TEST

(A) Sodium-Polysulphide Tinning Test

Any part of a tinned conductor removed from the core of the cable after the vulcanisation process is complete is to satisfy the following tests :—

1. Samples of the tinned wire are to be selected and bent into circles, the diameter of the circles being between 24 and 30 times the diameter of the wire. After cleaning by immersion in benzine and rubbing with a pad of clean cotton wool or filter paper to remove any grease, the samples are to be dried in air and the part to be immersed in the test solution is not to be handled.

2. Each sample is then to be immersed in test solutions, as stated below, and maintained at a temperature of approximately 60° F. (15·6° C.). The cycle of operation is to be performed six times. Each cycle is to consist of :—

First : Immersion of the sample for one minute in hydrochloric acid, as defined below, the sample then being washed in clean water and wiped dry.

Second : Immersion of the sample for 30 seconds in sodium-polysulphide solution, as defined below, the sample then being washed in clean water and wiped dry.

3. The sample is then to be examined under a hand lens to ascertain if copper exposed through openings in the tin coating has been blackened by the action of the sodium-polysulphide. The sample is to be considered to have failed if, by such blackening, exposed copper is revealed.

4. In the event of only one sample of a set giving results widely dissimilar from the remaining samples discretion may be exercised with regard to this sample.

5. Testing Solutions. The hydrochloric acid solution is to have a specific gravity at 60° F. (15·6° C.) of 1·088.

A portion of hydrochloric acid solution having a volume of 180 ml. is to be considered to be exhausted when there has been immersed in it the following number of test-samples :—

DIAMETER OF WIRE	Maximum number to be tested in 180 ml. of acid solution
Up to and including 0·044 in. ...	20
Above 0·044 in., up to and including 0·083 in.	12
Above 0·083 in.	8

The sodium-polysulphide solution is to have a specific gravity at 60° F. (15·6° C.) of 1·142 and is to be made in the following manner :—

Dissolve about 25 grammes of pure sodium-sulphide crystals in distilled water and make up to 100 ml., add powdered sulphur in excess of the quantity required to saturate the solution (about 25 grammes per 100 ml.), and boil for about one hour with occasional stirring.

Cool and filter the solution and then dilute with distilled water to a specific gravity of 1·142 at 60° F. (15·6° C.).

(B) Persulphate Tinning Test

As an alternative to the Sodium-Polysulphide Test the following may be used :—

1. Preparation of Test-Specimens.—(*a*) The insulation and coverings are to be removed from test samples of appropriate length (*see* following Table) by any method which does not cause injury to the tin coating.

(*b*) Two groups of specimens, each comprising the number shown in column 4 of the following Table, are to be marked 4 cm. from each end.

(*c*) Each specimen in the case of single conductors, or each group of 3 or 10 in the case of multiple conductors, is to be wound into one helix upon a smooth mandrel in such a manner as to ensure no twisting moment being imparted to the wire. Such portions as are necessary to lead up to the 4 cm. ends and provide for their projection above the

surface of the testing solution are not to be formed to the mandrel, but are to be suitably bent so as not to entail a radius less than half the diameter of the mandrel.

Test Samples				Test Specimens		
Diameter and number of wires comprising conductor			Length	Number	Length between marks	
Diameter		Number			For each specimen	Total for each group
1		2	3	4	5	6
(in.)			(cm.)		(cm.)	(cm.)
0·0076		10 or more	58	10	50	500
Above	Up to and including					
0·0076	0·012	6 or more	108	5	100	500
0·012	0·029	3 or more	74·7	3	66·7	200
0·029	0·103	3 or more	41·3	3	33·3	100
0·029	0·103		108	1	100	100

(*d*) After the test-helix has been removed from the mandrel and immediately prior to its immersion in the test solution it is to be cleaned by immersion for 10 seconds in a suitable solvent, i.e., chloroform or methylated ether in one vessel followed by a similar immersion in a second vessel and allowed to dry before immersion in the test solution.

In the event of rubber adhering to the test specimen, the wire is to be cleaned before or after winding the test-helix by rubbing with a pad of cotton wool soaked in the solvent, or by treatment with hot solvent. In no case, however, is the test-helix to be straightened and rewound or subjected to any serious mechanical deformation for the purpose of cleaning, and in all cases the double immersion described is to constitute the final cleaning operation.

2. **Preparation of Testing Solutions.**—The testing solutions are to be prepared as follows :—

(i) Persulphate Solution. Dissolve 10 grammes of fresh crystalline ammonium persulphate in distilled water, add 20 ml. of 0·880 ammonium hydroxide solution and make up to one litre with distilled water.

(ii) Standard Colour reagent. Dissolve 3,927 grammes of pure copper sulphate ($CuSO_45H_2O$) and 50 ml. of 0·880 ammonium hydroxide solution in distilled water and make up to one litre with distilled water. One ml. of this solution is equivalent to 0·001 gramme copper.

3. **Immersion for Test.**—After cleaning, the helix is to be immersed for 10 minutes in the persulphate solution in such manner that the surface of the wire between the marks (see Column 5 in preceding Table) is exposed to the solution and the 4cm. ends project above the surface.

The test is to be carried out under normal room temperature conditions, but immediately prior to the immersion test the solution is to be brought to a temperature of 60° ± 2° F.

The volume of the solution is to be :—

Up to and including 0·072 in. dia. ... 75 ml.

Above 0·072 in. dia. ... ... 200 ml.

The diameters of the mandrels to be used are to be in accordance with the Table below.

Diameter of Wire (in.)		Diameter of Mandrel (in.)
0·0076		0·60
Above	Up to and including	
0·0076	0·01	0·65
0·01	0·012	0·70
0·012	0·018	0·85
0·018	0·029	1·15
0·029	0·036	1·30
0·036	0·044	1·50
0·044	0·052	1·70
0·052	0·064	2·0
0·064	0·072	2·2
0·072	0·083	2·5
0·083	0·093	2·75
0·093	0·103	3·0

4. **Determination of Weight of Copper Dissolved.**—The weight of copper dissolved from the wire by the persulphate solution is to be determined colorimetrically by comparison with the standard colour reagent (*see* paragraph 2 (ii)). The weight is expressed as milligrammes of copper per square decimeter of wire immersed.

5. Standard of Quality.—If the result obtained does not exceed the appropriate value shown in the following Table the coating is to be regarded as satisfactory.

Diameter of wire (in.)		Milligrammes per square decimetre			
From	Up to and including	Ordinary Conductor Cables		Flexible Conductor Cables and Cords	
		Other than Tough-Rubber Sheathed	Tough-Rubber Sheathed	Other than Tough-Rubber Sheathed	Tough-Rubber Sheathed
1	2	3	4	5	6
0·0076	0·018	—	—	40	50
0·0181	0·103	30	30	30	30

If the result of one group exceeds the limiting value the test may be repeated from a fresh group comprised of specimens from the same cable from which the original defective group were taken, in order to ensure that the failure is not due purely to end effect.

If this additional group also fails, the cable is to be rejected.

APPENDIX 8

SPARK TESTING OF RUBBER INSULATED CABLES

1. Spark testing can be applied to 250-volt and 660-volt vulcanised rubber insulated cables and fire-resisting polychloroprene insulated cables, flexible cables and flexible cords having conductors of a maximum cross-sectional area of 0·06 sq. in. as an alternative to insulation resistance and voltage tests.

2. The test is to be taken at the core stage, except for single-core, braided and compounded cable, in which case it may be taken at the finished stage as an alternative to the core stage.

3. The test electrode is to make intimate contact with the surface of the core or cable and shall preferably consist of a fine link mesh. The speed at which the core or cable passes through the electrode is to be such that every point is in the electrode for not less than 0·1 second.

4. The supply to the electrode is to be alternating current at 50 cycles per second. The conductor of the core or cable is to be earthed and the potential difference between the electrode and the conductor is to be in accordance with the following:—

Grade of Cable	R.M.S. Test Voltage
250-volt	volts
Up to and including 0·0225 sq. in. ...	6,000
Above 0·0225 sq. in. up to and including 0·04 sq. in.	8,000
Above 0·04 sq. in. up to and including 0·06 sq. in.	10,000
660-volt	
Up to and including 0·04 sq. in.	10,000
Above 0·04 sq. in. up to and including 0·06 sq. in.	12,000

5. The detector is to be so arranged as to maintain fault indication even after the fault has passed out of the electrode.

The minimum sensitivity of the spark-testing apparatus is to be such that the detector will operate when an artificial fault device consisting of a spark gap in series with a capacitor is connected between the electrode and earth. The electrode potential is to be 6,000 volts RMS and the capacitor 350 micro-microfarads. The spark gap is to consist of a metal plate moving past a needle point in 0·02 seconds, and the distance between them during this time is to be 0·2 inch. Check tests are to be taken at regular intervals.

APPENDIX 9

CURRENT RATINGS OF CABLES

1. The Tables apply to cables employed in the wiring of ships but do not provide for every condition under which cables may be used.

The current ratings and lengths set out are calculated for full-load conditions based on experimental data, and are based on maximum operating conductor temperatures of 124° F. (51° C.) for vulcanised-rubber insulated cables and 160° F. (71° C.) for lead sheathed impregnated-paper-insulated and varnished-cambric-insulated cables. They have been rounded off to apply, under practical conditions, to the respective cables and methods of installation defined in the Tables.

It is impracticable to specify ratings for every condition of grouping and of loading which may occur in ships, but guidance can be furnished for specific cases if desired.

The cooling air temperature referred to in the Tables is the temperature of the air under normal conditions, and does not take account of increase of temperature in the vicinity of cables due to heat arising therefrom.

2. The permissible ratings, subject to voltage drop, of cables run on cleats are generally higher than those run in clips, conduit or wood casings, and further particulars can be supplied on request.

3. In a three-phase system of single-core cables in flat formation passing through a steel bulkhead, each cable passing through a separate hole in steel, no direct effect need be anticipated on the current rating or voltage drop except in extremely short connections. Heating of the steel, however, results from the magnetic effects, the temperature rise at the hottest point amounting to twice the conductor temperature rise under unfavourable conditions. In confined spaces this may lead to increased cable temperatures unless a non-magnetic gland plate is used, non-magnetic glands or bushings giving at least $\frac{3}{8}$-in. clearance between the lead sheath and the steel should be used and the axial spacing between the cables should, where possible, be not less than 6 inches.

APPENDIX 10

TRANSFORMERS FOR POWER AND LIGHTING

1. Transformers, unless otherwise approved, are to be rated at their continuous maximum rating expressed as the kVA output on non-inductive load when carrying rated current on the output side with rated voltage applied on the input side. This Appendix relates to transformers rated at 1 kVA or over if single-phase, and 5 kVA or over if polyphase.

2. The temperature rise, when tested at the continuous maximum rating is not to exceed the limits given in the table below.

The temperature-rise limits specified for natural air cooling and air blast cooling, whether for dry or oil-immersed transformers, are temperature rises above the ambient air temperature, and for water cooling are temperature rises above the inlet water temperature. The standard reference ambient temperature for the purpose of these requirements is 85° F. (29·5° C.) in the case of sea water cooling, while for air it is 113° F. (45° C.).

TEMPERATURE RISE LIMITS ON TRANSFORMERS WITH DIFFERENT TYPES OF COOLING

WINDINGS—Average temperature rise as measured by increase in resistance of the winding connected between the terminals.

Type	Oil Circulation	Cooling	Insulation	
			Class A	Class B
1	2	3	4	5
Dry	—	Air Natural Air Blast	90° F. (50° C.)	126° F. (70° C.)
Oil-immersed	Natural thermal head only	Air Natural Air Blast Water	99° F. (55° C.)	—
	Forced Circulation by external pumps	Air Natural	108° F. (60° C.)	—
		Air Blast	108° F. (60° C.)	—
		Water	117° F. (65° C.)	—

OIL—For all oil-immersed types, temperature rise by thermometer—81° F. (45° C.).

CORES—For all types, the temperature rise when measured by thermometer on the external surface of the core is not to exceed that permitted for the adjacent windings.

3. All transformers while in service are to be capable of withstanding short-circuit without injury for the time periods given below, normal line voltage being maintained.

DURATION OF SHORT-CIRCUIT WITH REFERENCE TO IMPEDANCE VOLTAGE

Impedance Voltage	Duration of Short-Circuit in seconds
4%	2
5%	3
6%	4
7% and above	5

Transformers having an impedance less than 4 per cent are to be capable of withstanding, under service conditions, 25 times normal full-load current for two seconds.

4. The voltage ratio is to be within 0·5 per cent of the declared ratio, or a percentage equal to 1 tenth of the percentage impedance voltage at rated load, whichever is the smaller.

5. An applied high voltage test is to be carried out on every transformer at the manufacturer's works, preferably with the transformer hot immediately after the temperature test, if any. The test is to be applied between the winding under test and the remaining windings, frame and tank of the transformer all connected to earth.

The test is to be made with alternating-current at any convenient frequency between 25 c/s and twice the rated frequency of the transformer, but preferably at the rated frequency. The full test voltage is to be maintained for one minute.

APPLIED VOLTAGE TEST

NOTE.—In the Table "E" denotes the service voltage in kV (between lines).

System and No. of Phases	Test Voltage in kV		
	System with Neutral or Centre Point Insulated or Earthed through current-limiting device	System with Neutral or Centre Point earthed direct	
	Transformer not earthed or earthed through current-limiting device	Transformer	
		Not earthed	Earthed direct
Single-phase	1+2E	1+1·73E	1+1·4E
Two-phase	1+3·46E	1+3·46E	1+2·8E
Three-phase	1+2E	1+2E	1+1·6E

Single-phase transformers for use in a polyphase group are to be tested in accordance with the requirements for the transformers as connected together on the system.

6. An induced high voltage test is to be carried out on every transformer at the manufacturer's works, in which a voltage is applied across the terminals of one winding of the transformer sufficiently in excess of its rated voltage to induce voltages of the specified test magnitudes in all windings. This test is made by utilising an external source of voltage usually having the same number of phases as the transformer under test and provides a graduated test of the insulation between separate windings and the adjacent parts, and also a test of the inter-turn and inter-coil insulation.

The test is to be carried out as follows:—

To the terminals of either the higher- or lower-voltage windings is to be applied an A.C. voltage of as nearly as possible sine-wave form and at approximately twice the rated frequency to avoid excessive exciting current during the test. The windings not connected to the exciting source are to be left on open circuit, and steps taken to ensure that excessive voltages do not occur during the test. Any winding may be earthed at any point at the discretion of the manufacturer during this test.

The test voltage between the line terminals or between one line terminal and neutral is to be twice the normal voltage between these terminals under working conditions. The test is to be commenced at about one-third of the test voltage and is to be increased to its full value as rapidly as is consistent with its magnitude being indicated by the measuring instrument. The standard duration of the test is 60 seconds for any test frequency up to and including twice the rated frequency. When the test frequency exceeds twice the rated frequency the duration of the test in seconds is to be equal to:—

$$60 \times \frac{2 \times \text{rated frequency}}{\text{test frequency}}$$

but in no case is the duration of the test to be less than 15 seconds. At the end of the test, the voltage is to be diminished rapidly to one-third of the test voltage before switching off.

In the case of three-phase transformers in which the induced voltage test is applied as a single-phase voltage and the resultant voltage therefrom between adjacent line terminals does not reach twice the rated voltage, a supplementary test with the same or other circuit connections is to be made in order to obtain the specified voltage between line terminals.

7. In the case of repairs affecting the windings of a transformer which has been in service, the transformer is not to be put back into service after such repair until it has passed high voltage tests using test voltages equal to 75 per cent of those prescribed above.

APPENDIX 11

INSULATING RUBBER FOR CABLES

Physical tests and requirements

(*a*) *Samples.*

Eleven samples of the completed core are to be stripped of the proofed tape (if any) and the conductors are to be carefully removed without damaging the rubber insulation.

(*b*) *Preparation and condition of samples.*—

(i) Tests are to be made not less than 72 hours after the vulcanisation of the rubber.

(ii) Samples are to be protected from light as completely as practicable.

(iii) Samples that have been subjected to accelerated ageing are to be tested not less than 24 hours and not more than 72 hours after removal from the ageing oven.

(iv) All samples are to be kept at a temperature of 21° C.±3° C. for a period of not less than 24 hours and not greater than 72 hours immediately before being tested, and during test.

(*c*) *Sub-permanent set.*

Two of the samples are to be marked with lines 2 inches apart, after which they are to be stretched until the lines are 6 inches apart (200 per cent elongation) and maintained so stretched for 4 hours. The samples are then to be released and exactly 2 hours after release the distance between the marks is to be measured. The mean distance, for the two samples, is not to exceed 2·60 inches (30 per cent sub-permanent set) and they are to show no signs of furring or cracking.

(*d*) *Tensile strength and elongation at break.*

Nine samples are to be cut accurately to a convenient length and eight of them marked with lines 1 inch apart. The unmarked sample is to be used for the determination of the density of the compound. Each of the other samples is to be weighed and the mean cross-sectional area calculated from its weight, length and density.

Four of the marked samples are to be tested for tensile strength and elongation at break on a machine having grips of the self-tightening type. The rate of separation of the grips is to be such that the portion between the marks on the sample is stretched to breaking at a rate approximating to 500 per cent elongation per minute.

The tensile strength and elongation at break of each of the four samples is to be recorded. The sample with the lowest figure for tensile strength is to be neglected and the average values of tensile strength and elongation at break of the other three calculated and recorded as the values for the unaged insulant.

The values are to be not less than the following :—

Size of cable	Breaking weight in lb. per sq. in.	Elongation per cent
Cables with insulant of <0·030 inch radial thickness	1800	360
Cables with conductor diameter of 0·32 inch or greater	1600	320
All other sizes	2000	400

(*e*) *Accelerated ageing.*

The remaining four samples are to be maintained in the dark in a ventilated air oven at a temperature of 82·2° C.±0·5° C. for 120 hours. After conditioning in accordance with sub-paragraph (*b*) (iii) of this clause the tensile strength and elongation at break is to be determined in accordance with sub-paragraph (*d*). The tensile strength and elongation at break of the aged samples is to be not less than 75 per cent and 85 per cent respectively of the unaged values.

Chapter N

REFRIGERATED CARGO INSTALLATIONS

Extract from Chapter B for reference

B 901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Refrigeration Section of the Appendix to the Register Book.

B 902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port, and other Surveys set forth in N 8.

Section 1

GENERAL

Class Notation

101 The class notation assigned will be Lloyd's RMC followed by the minimum temperature(s) approved by the Committee for the installation with the maximum sea temperature stated, e.g. "to maintain temp. 10° F. in the lower and 31° F. in the upper chamber with sea temperature 85° F. maximum."

NOTE.—The temperature at which the cargo is to be carried is not the responsibility of the Society.

102 Installations constructed under the Society's Special Survey in accordance with N 2 to N 6 will be eligible for the distinguishing mark ✠ before the class notation, thus ✠Lloyd's RMC. In other cases the mark ✠ will not be assigned.

103 In the case of installations designed to reduce the temperature of non-precooled cargoes a mark ‡ will be shown under the class notation in the Appendix to the Register Book and will be included on the certificate as an indication that an installation has been considered by the Society for this duty. A special statement showing the cargo cooling capabilities of such installations, in respect of stated weights and descriptions of cargoes under stated conditions, will be issued on application by the Owners to the Society's Head Office.

Special Cases

104 The Committee will be prepared to give consideration to cases of ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases the class may include a service limitation or other restriction.

NEW INSTALLATIONS

Section 2

SPECIAL SURVEY DURING CONSTRUCTION

201 New installations intended for classification are to be constructed under the Society's Special Survey in accordance with the requirements of N 3 and N 4; tests are to be carried out as specified in N 5, and spare gear is to be supplied as listed in N 6.

Information and Plans to be Submitted

202 The following information and plans are to be forwarded for consideration before construction is commenced:—

(*a*) Refrigerating plant—standard data sheet in duplicate. (Copies of this data sheet may be obtained from the Society's local office.)

(*b*) Refrigerating plant — detailed specification in triplicate.

(*c*) Insulation—detailed specification in triplicate.

(*d*) General arrangement of insulated chambers in elevation and plan. The plans are to be to a scale of not less than $\frac{1}{4}$ inch to the foot and adequate for the measurement

of the external surfaces and the deck and bulkhead edges. Dimensions and spacing of frames, beams and stiffeners and details of other steel work protruding into the insulation and within the chambers are to be shown. Oil fuel and liquid cargo tanks adjacent to or below the chambers are to be indicated, and whether heating is provided for such tanks. Ventilating and air conditioning trunks and ducts passing through chambers are to be shown. The plans should include a diagram showing the position of the chambers in relation to other parts of the ship if this is not otherwise apparent.

(*e*) Detailed plans showing the thickness and methods of attachment of the insulation and linings on all surfaces, including girders, hatch coamings and pillars; details of insulated doors, and hatch, access, bilge and manhole plugs and their frames. Method of attachment of brine or direct expansion grids and meat rails are also to be shown.

(*f*) Arrangement of air ducts (including method of cooling spaces within hatch coamings), air coolers, fans and their motors.

(*g*) Air cooler defrosting arrangements, other than hot brine circulating systems.

(*h*) Arrangement of brine grids including those in way of hatches; and method of construction.

(*i*) Arrangement of chamber thermometers.

(*j*) General arrangement of refrigerating machinery.

(*k*) Brine circuit diagram with particulars of piping.

(*l*) Primary refrigerant gas and liquid circuit diagrams and full particulars of all pressure piping.

(*m*) Sectional arrangement of refrigerant compressors.

Detailed dimensioned plans of:—

(*n*) Compressor crank shafts.

(*o*) Compressor crank cases where exposed to the refrigerant pressure.

(*p*) Condensers.

(*q*) Evaporators (brine coolers).

(*r*) Air coolers.

(*s*) Oil separators.

(*t*) Liquid receivers.

(*u*) All other pressure vessels.

NOTE.—All the plans listed, and any others which may be specially requested are to be forwarded in triplicate.

(*v*) Similar plans are required for refrigerating plant of other designs.

(*w*) Where the refrigerating machines are driven by oil engines particulars and plans are to be submitted in accordance with the requirements of G 104 and H 7.

(*x*) Where the refrigerating machines or air cooler fans are driven by steam engines particulars and plans are to be submitted in accordance with G 104.

(*y*) Where air cooler or necessary air stirring fans are electrically driven plans of the motors are to be submitted in accordance with M 1207.

Refrigeration required in excess of N 306

203 Refrigeration required in excess of that specified in N 306, which may be necessary for rapid cooling of chambers, or cooling cargoes loaded at temperatures above the carrying temperature, is to be in accordance with a specification approved by the Owners.

Rate of Air Circulation

204 Where refrigeration is effected by forced air circulation over coolers the proposed fan output in each chamber will be considered in relation to the heat to be removed, the nature of the cargo and the service(s) intended.

Where chambers are intended for the additional duties mentioned in 203 the rate of air circulation is to be in accordance with the Owners' requirements.

Subsequent Modifications or Additions

205 Any subsequent modifications or additions to particulars and/or arrangements shown on the approved plans or in the specifications are also to be submitted for approval.

Novel Arrangement and Designs

206 Where the proposed construction of the refrigerating plant or refrigerated chambers is novel in design or involves the use of unusual material, special tests may be required, and a suitable class notation may be assigned when the Committee consider this necessary.

Survey Requirements

207 From the commencement of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to examine the materials and workmanship and are to indicate at the earliest opportunity and require the rectification of any items not in accordance with the Rules or the approved specifications and plans, or any material, workmanship or arrangement found to be defective or unsatisfactory.

Section 3

REFRIGERATING PLANT

Definition of a Unit

301 A refrigerating unit comprises a prime mover, one or more refrigerating machines (refrigerant gas compressors), one gas condenser—and in the case of a secondary refrigerant, one brine cooler (gas evaporator)—and the fittings necessary to permit independent operation of the unit.

302 If the prime mover of a refrigerating machine is a steam engine with two or more cylinders and each cylinder drives a corresponding compressor, or there is more than one motor similarly arranged, and if each compressor is connected to its own condenser and brine cooler (where fitted), the arrangement is to be regarded as two or more units as the case may be, provided the units can be used separately or in combination.

NOTE.—Condensers or evaporators of the coil-in-casing type need not necessarily be in separate casings.

303 Two or more refrigerating machines (or compressors) driven by a single prime mover, or having only one condenser or one brine cooler (where fitted), are to be regarded as one unit.

304 Where a refrigerating plant is provided for sub-cooling the liquid refrigerant, or cooling the condensers of other refrigerating machines, and is not arranged for cooling the cargo spaces independently, it will not be regarded as a unit.

305 Where a refrigerating plant is dependent on the main refrigerating units for cooling the condenser or the refrigerant liquid, it will not be regarded as a unit.

Refrigeration to be Provided

306 The refrigeration provided is to be capable of efficiently maintaining the minimum temperature(s) under the conditions applicable to the maximum sea temperature for which approval by the Committee is desired and which is to be specified in the class notation (*see* N 101), when working 24 hours a day with any one of the refrigerating units out of action. It is recommended that a reasonable margin in plant output over maximum load be allowed for possible overall inefficiencies under service conditions.

307 Where part of the necessary refrigeration is obtained by the sub-cooling of the liquid refrigerant by other refrigerating plant, one plant supplying such sub-cooling may be considered sufficient provided the refrigerating units including the stand-by unit are capable of the full duty specified in 306 in the event of the sub-cooling plant being out of action.

308 In any case where all the refrigerating units are not connected for use on all the refrigerated cargo chambers the plant serving each chamber is to comply with the requirements of 306.

309 The foregoing requirements are based on the assumption that installations will have relatively few refrigerating units each arranged to serve all chambers. In the case of installations having a large number of small units arranged to serve individual chambers, or groups of chambers, the question of reserve plant will be the subject of special consideration.

Number of Refrigerating Units

310 Not less than two complete refrigerating units are to be fitted. Where two units only are fitted the working parts are to be interchangeable.

Stand-by Pumps

311 A stand-by gas condenser cooling water pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306. This stand-by pump may be one of the pumps used for other purposes provided it is of adequate capacity and its use on the gas condenser does not interfere with other essential services.

312 Where brine is used for refrigerating the cargo chambers a stand-by brine circulating pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306.

Sea Connections

313 Condenser cooling water is to be taken from not less than two sea connections, one of which may be that provided for other purposes, such as the water ballast inlet. It is recommended that one of the sea connections be provided on the port and the other on the starboard side.

Location of Machinery

314 Where ammonia or methyl chloride refrigerant is used the machinery is to be in an efficiently ventilated compartment isolated from the propelling machinery spaces including the shaft tunnels.

Prime Movers

315 Where refrigerating plant is electrically driven the motors and their control gear are to comply with the requirements of M 12 and M 13.

316 Where the refrigerating machinery is steam driven the steam engines are to comply with the requirements of Chapters G and H and the exhaust steam is to be led to the main and auxiliary condensers.

317 Where the refrigerating machinery is driven by oil engines the requirements of Chapters G and H are to be carried out.

Motive Power

318 In the case of 315 the electric power is to be taken from at least two generators (*see also* M 233) and in the case of 316 steam is to be taken from at least two boilers, each capable of the maximum duty without interference with other essential services.

Plant on Ships not classed with the Society

319 In the case of refrigerating installations being constructed under the Society's Special Survey on ships not intended to be classed with this Society, the generator engines and electrical equipment, which supply power to the refrigerating installations, should be constructed in accordance with the requirements of the Classification Society concerned, but such plant is to be examined generally and under working conditions.

Steel Castings

320 Important steel castings are to comply with the requirements of P 9.

Steel Forgings

321 Crank shafts and other important steel forgings are to comply with the requirements of P 10.

Dimensions of Crank Shafts

322 Crank shafts of single acting reciprocating refrigerant compressors, of mild steel having a tensile breaking strength of 28/32 tons per square inch are to have dimensions not less than those calculated from the following formulæ.

323 The formulæ are applicable to compressors operating on the normal cycle, with crank shafts having one, two, three or four cranks at equal angles and one cylinder acting on each, and with two or more main bearings.

324 The formulæ are also applicable to compressors, other than CO_2, having the crank and cylinder arrangements as shown in the following table, but in these cases the calculated shaft diameter is to be increased by 5%, 18% and 25% when the angle between cylinders is 90°, 60° and 45° respectively.

Number of crank pins	Number of cylinders per crank	Angle between cylinders
1 or 2	2	45°, 60° or 90°
3	2	45° or 60°
4	2	45° or 60°
1	3	45°, 60° or 90°
2	3	45° or 60°
3	3	45°
1	4	45° or 60°
2	4	45°

325 The formulæ are not applicable to crank shafts having more than one crank on the same top centre, or to compressors where the cylinders are arranged for supercharging by gas of higher pressure at an intermediate stage of the stroke.

Diameter of Crank Shafts

326

Refrigerant	Diameter of crank shaft (All dimensions in inches or millimetres)
Carbon Dioxide (CO_2)	$\sqrt[3]{D^2\left(15\frac{ab}{a+b}+1{\cdot}25S\right)}{12}$ for gas discharge pressures up to 1500 lb. per square inch.
Ammonia (NH_3) Monochlorodifluoromethane ($CH\,Cl\,F_2$)	$\sqrt[3]{D^2\left(2{\cdot}5\frac{ab}{a+b}+0{\cdot}15S\right)}{12}$ for gas discharge pressures up to 250 lb. per square inch.
Dichlorodifluoromethane ($C\,Cl_2\,F_2$) Methyl Chloride ($CH_3\,Cl$)	$\sqrt[3]{D^2\left(1{\cdot}5\frac{ab}{a+b}+0{\cdot}1S\right)}{12}$ for gas discharge pressures up to 150 lb. per square inch.

where D=cylinder diameter,

S=length of stroke,

a=distance from the inner edge of one bearing to the centre line of the crankpin nearest the centre of the span,

b=distance from the centre line of the same crankpin to the inner edge of the other bearing,

a+b=distance (or span) between the inner edges of adjacent main bearings.

Crank Webs

327 Crank webs are to be of the following proportions or of equivalent strength:—

Breadth of web = 1·33 × calculated shaft diameter.

Thickness of web adjacent to a bearing = ·56 × calculated shaft diameter.

Thickness of intermediate webs = ·75 × calculated shaft diameter.

Crank Shafts of Other Materials

328 Where crank shafts are proposed to be made of steel of greater strength or of other material, the particulars including the material specification are to be submitted for special consideration.

Crank Shafts for Compressors of Other Designs

329 The particulars of crank shafts for double acting or compound compressors, and for other refrigerants or arrangements, are to be submitted for special consideration.

Maximum Working Pressures

330 The components of primary refrigerant pressure systems including piping, stop valves and headers are to be designed for a maximum working pressure of not less than:—

1500 lb. per square inch for carbon dioxide (CO_2)

250 lb. per square inch for ammonia (NH_3) and monochlorodifluoromethane ($CH\ Cl\ F_2$)

150 lb. per square inch for dichlorodifluoromethane ($C\ Cl_2\ F_2$) and methyl chloride ($CH_3\ Cl$))

In the case of crankcases which are exposed to the refrigerant pressure the design pressure is to be not less than:—

200 lb. per square inch for ammonia and monochlorodifluoromethane

100 lb. per square inch for dichlorodifluoromethane and methyl chloride

Crankcases designed for a lower pressure are to be provided with a pressure relief valve arranged to lift at the design pressure and the discharge led to a safe place.

If desired a lower design pressure may be considered for other parts of the low pressure side of the system.

The design pressure for other refrigerants which may be proposed will be considered on application, but as a general guide this will be the saturated vapour pressure at 115° F.

Refrigerant Pressure Vessels

331 Welded cylindrical pressure vessels which are of steel construction and exposed to the pressure of the refrigerant are to be constructed in accordance with the requirements of J 18 to J 23 so far as applicable, except that the pressure tests are to comply with 339.

332 Where ammonia is the refrigerant, pressure vessels are to be constructed to not less than Class 2 fusion welded or Class 1 forge welded requirements.

333 Where pressure vessel shells are made of steel tube the tubes are to comply with the requirements of E 5 so far as applicable, except that the formula for determining the thickness of straight shells may be modified to

$$t = \left(\frac{WP \times D}{2f} + \cdot 03\right) 1 \cdot 15$$

334 Where ammonia is the refrigerant, pressure vessel shells are not to be manufactured from lap welded pipes.

335 Where pressure vessels are of seamless construction, they are to comply with the requirements of J 2404 to J 2406, and the pressure tests are to comply with 339.

336 Where it is proposed to construct pressure vessels of materials other than steel, or not of cylindrical form, full particulars will be required for special consideration.

Pressure Pipes

337 Steel piping for primary refrigerants is to comply with the requirements of E 5 except that the figure of ·05 may be reduced to ·03 and the pressure tests are to be in accordance with 339.

Butt welding of pipe lengths in lieu of flanged joints is to be carried out by a method approved by the Committee, under the supervision and to the satisfaction of the Society's Surveyors, including such weld tests as may be required.

338 Where it is proposed to use pipes of materials other than steel, full particulars are to be submitted for consideration.

Pressure Tests

339 The pressure tests which follow are to be witnessed by the Society's Surveyors at the maker's works. The hydraulic test may be carried out with any suitable liquid. When it is inconvenient to test large NH_3 (ammonia) condensers and evaporators by submersion in water the shells may be charged with air and gas, and tested by

some suitable means. In the case of C Cl_2 F_2 (dichlorodifluoromethane), CH Cl F_2 (monochlorodifluoromethane) and CH_3 Cl (methyl chloride) a suitable gas may be used in lieu of air.

Refrigerant	Component	Minimum Test Pressure lb/in²	
		Hydraulic	Air*
CO_2	Compressor cylinder blocks, stop valves and connections, connecting piping, separators, condenser and evaporator coils and all components subject to gas pressure.	3,000	1,500
NH_3 and CH Cl F_2	Compressor cylinders, stop valves, connections and all piping.	600	300
	Compressor crankcases subject to refrigerant pressure.	300	150
	Condenser, evaporator and air cooler coils.	1,500	500
	Condenser and evaporator coils or grids welded to headers; condensers and evaporators of double pipe or "shell and tube" types; pressure vessels, and all other components subject to gas pressure.	500	250
C Cl_2 F_2 and CH_3Cl	Crankcases subject to refrigerant pressure.	200	150
	Small machines with cylinders up to 4½" dia. where the cylinders and crankcases are in one casting.	300	200
	All other components in the entire system, including piping.	350	200
	Cooling liquid side of refrigerant condensers.	2WP but not less than 15	
Brine	Air cooler coil assembly.	100	
	Cast iron casings of refrigerant evaporators.	2WP but not less than 15	
	Steel casings of refrigerant evaporators on suction side of pump.	2 × head pressure but not less than 30	
	Steel casings of refrigerant evaporator on discharge side of pump.	2WP but not less than 50	
	Open casings of brine evaporators.	Filled to top	

* Component submerged in water at 90° F.

Tests after Erection on Board Ship

340 Carbon dioxide systems are to be examined for gas leaks when the system is charged. Ammonia and monochlorodifluoromethane systems are to be tested to a gas or air pressure of not less than 200 lb. per square inch.

Dichlorodifluoromethane and methyl chloride systems are to be tested by a suitable gas to a pressure of not less than 100 lb. per square inch.

Brine systems are to be tested to a hydraulic pressure of double the working pressure but not less than 50 lb. per square inch. Where the hydraulic test is not reasonably possible, sections of brine leads (service pipes) which have to be insulated before the circuits are complete may be tested by an air pressure of 90 lb. per square inch.

Oil Separators

341 Suitable oil separators with drains are to be provided to the refrigerant lines. If wire gauze is used in the separator it is to be sufficiently robust and supported to prevent disintegration.

Filters (strainers)

342 Suitable filters are to be provided in the refrigerant gas lines to compressors and in the liquid lines to the regulators. Wire gauze in filters is to be sufficiently robust and supported to prevent disintegration. A filter may be combined with the oil separator required by 341.

Refrigerant Driers

343 Driers are to be fitted in monochlorodifluoromethane, dichlorodifluoromethane and methyl chloride refrigerant systems, and the arrangement is to be such that the drier can be by-passed, isolated and opened up without interrupting plant operation.

Brine Systems

344 Where brine is the cooling medium it is recommended that the "closed" system with a brine balance tank be adopted in every case.

Safety Devices

345 A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor.

346 All pressure vessels of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, or other approved arrangements, the discharge being led to a safe place above deck.

347 Suitable spring-loaded safety valves are to be provided to the cooling liquid side of condensers and the brine side of evaporators where the pressure from any pump connected could cause a pressure in excess of the maximum working pressure.

Access to Plant

348 The arrangements are to be such that all components of the refrigerating machinery can be readily opened up for inspection or overhaul. Space is to be

provided for the withdrawal and renewal of the tubes in "shell and tube" type evaporators (brine coolers) and condensers.

349 Where the coils of "coil-in-casing" type evaporators (brine coolers) and condensers are unwieldy and cannot readily be withdrawn, two suitably arranged inspection holes are to be provided in the top plate, in the sides at about half height and in the sides at the bottom. The holes are to be as large as practicable and not less than 9 inches × 6 inches.

Manual Control

350 Where plants are operated by thermostatic refrigerant control, efficient manual controls are also to be provided, and the arrangement is to be such that thermostatic controls can be by-passed and isolated.

Refrigerating Plant of Other Design

351 Particulars of refrigerating plant of designs other than those mentioned in these Rules (e.g., steam jet vacuum refrigeration plants) are to be submitted for special consideration.

Cooling Appliances in Refrigerated Chambers

352 Chambers may be refrigerated by pipe grids on the ceiling and sides or by the circulation of air overcoolers.

353 Refrigeration by pipe grids in the chamber is to be effected by the circulation of brine, except in the case of installations or chambers of very small capacity when the direct expansion of the refrigerant will be considered. The pipe grids in each chamber are to be arranged in not less than two sections. Each section is to be fitted with valves or cocks so that it can be shut off.

354 Either brine or the direct expansion of the refrigerant may be employed in the coils of air coolers. The coils are to be arranged in not less than two sections each of which is to be capable of being readily isolated when necessary.

355 The brine or direct expansion leads to, and returns from, the cooling appliances in each chamber are preferably to be in duplicate.

356 In order to minimize the dehydration of the cargo and the frosting of the cooling elements, it is recommended that the cooling appliances in each chamber should be designed to maintain the required minimum temperature under the maximum external conditions with a mean temperature difference of not more than 8° F. between the cooling medium and the chamber.

357 Where the joints of brine pipes are made by screwed couplings, the pipes, coupling and back nut threads are to be a good fit and the thickness of the pipes at the bottom of the screw thread is to be not less than 3/32nds of an inch.

358 Where the joints of air cooler and grid piping are butt welded they are to comply with 337.

359 Steel brine and refrigerant piping, grids, joint sleeves and coils within the refrigerated cargo chambers, or where embedded in insulation, or individually insulated are to be galvanized externally. Where brine pipes are connected by screwed couplings, the screw thread clear of the coupling is to be suitably coated or taped after erection to prevent corrosion.

360 Brine tanks and piping should not be galvanized on the brine side. In cases where any parts of the brine system are so treated, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be removed. Where the brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

361 Means are to be provided for defrosting air coolers.

362 Air coolers are to be provided with trays of suitable depth arranged to collect all water condensate. The trays are to be provided with drains at the bottom so that the whole of the condensate can be drained away when the chambers are in service.

363 Access arrangements to air cooler fans and fan motors are to be such that both fans and motors may be readily removed for repair or renewal when the chambers are loaded with refrigerated cargo. Access for servicing only is required in cases where duplicate fans and motors, each capable of the full duty, are installed ready for use; this also applies to centrifugal type fans but not to their motors.

364 The air circulation system is to be arranged for positive air delivery to, or suction from, all parts of the chamber, including any space within hatch coamings.

365 Where it is intended to carry fruit cargoes, which may be adversely affected by low temperatures, into sea areas where the temperature may be below the carrying temperature, facilities for heating the chambers are to be provided.

Air Refreshing Arrangements

366 Where chambers are intended for the carriage of gas generating cargoes, air refreshing appliances are to be provided.

The position of the air inlets is to be carefully selected to minimize the possibility of vitiated air from any source entering the chambers. Each chamber is to be provided with individual inlets and discharges, having airtight closing appliances.

Section 4

CARGO CHAMBERS

Construction

401 Each individual chamber is to be of steel construction throughout and hose-tested for tightness, or tested more thoroughly by gas and air under slight pressure when required by the Owners.

402 At the request of Owners, special consideration will be given to the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers where the chambers concerned are intended for cargoes which will not taint or otherwise adversely affect the cargo in any other chamber.

NOTE.—Gases given off by one description of fruit may adversely affect other descriptions by promoting rapid ripening.

403 Hatch plugs and their supports, chamber, air cooler and other access doors, tonnage openings, bilge limbers and plugs are to be made as airtight as possible.

404 Ventilators, ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight and efficiently insulated. Ventilators to refrigerated spaces, if fitted, are to be provided with airtight closing appliances.

Airtightness of the Bulkheads and Decks

405 Where refrigeration pipes pass through bulkheads or decks of refrigerated cargo chambers they are not to be in direct contact with the steelwork, the holes through which they pass are to be true and of suitable finish for effectively sealing by the method intended. It is recommended that holes be trepanned and not burnt out. The airtightness of the bulkheads and decks is to be maintained (*see also* 408 and 413).

Airtightness of Chambers

406 The foregoing paragraphs, 401 to 405, are mainly concerned with infiltration of odours, gases, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause undesirable frosting of cooling equipment. With this object in view it is also recommended that insulation lining, bilge limbers and plugs, hatch plugs, chamber and access doors be constructed of water vapour resisting material, or covered with such material, and sealed, where exposed to bilges or external conditions.

Insulation

407 Steelwork is to be thoroughly cleaned and coated in accordance with D 3004 and D 3005 and is to be examined for airtightness of fittings before insulation is applied.

Insulating material approved by the Committee is to be used throughout, and the thickness of insulation over all surfaces and the manner in which it is supported are to be in accordance with the approved specification and plans.

The insulation is to be efficiently packed and, where it is of slab form, the joints are to be butted closely together and staggered, unavoidable crevices being filled with insulating material. Bitumen should not be used for filling crevices.

408 Pipes carrying the refrigerating medium are not to be in contact with the steel structure and are to be effectively insulated outside the chambers they serve, except within insulated brine cooler and control rooms (*see also* 405 and 413).

Cross-references

409 For insulation of oil storage tank tops and bulkheads, *see* E 341 and E 342.

For pipes in refrigerated spaces, *see* E 417.

For drainage of refrigerated spaces and cooler trays, *see* E 211 to E 216.

Protection of Insulation

410 The insulation in way of the hatchways and about 2 feet beyond on the tank top and the tunnel top is to be protected with hardwood sheathing about 2 inches thick, or to have similar protection.

Access Plugs and Panels

411 Insulated plugs are to be provided in the insulation where required for easy access to the bilges, bilge suction roses, cooler and space drains and tank manhole doors. Removable panels are to be provided for access to tank air and sounding pipes and drains.

It is recommended that, where no air space is provided below the insulation on the tank tops and the floor covering above the insulation is reinforced asphalt, a number of small insulated inspection plugs be fitted for leakage detection.

Where "loose fill" insulation is fitted and lined with metal it is recommended that airtight inspection plates be provided at the top of vertical surfaces to facilitate inspection and making good any settlement.

Fire-resisting Insulation

412 The insulation in way of coal bunkers and of any surfaces exposed to excessive heat is to be of approved fire-resisting material. Where wood grounds are used for supporting insulation, asbestos strips are to be fitted between the wood grounds and the steel-work to which they are attached.

Where pipes carrying the refrigerating medium pass through bunkers the pipes may be packed with granulated cork but there is to be a thick outer covering of fire-resisting material and the whole is to be protected by steel plates which are to be sealed for airtightness.

Watertight Bulkhead Fittings

413 Where cooling pipes pass through watertight deck plating and bulkheads, the pipes are not to be in contact with the steelwork, and the fittings and packings of the glands are to be both fire-resisting and watertight (*see also* 405 and 408).

Airtightness of Insulation Lining and Air Ducts

414 Air ducts and insulation linings are to be so constructed and fitted that moving air is prevented from entering the insulation. Special care is necessary where cooling pipes, air refreshing ducts, fan supports, etc., protrude through the lining.

Cargo Battens

415 Cargo battens of about 2 inches × 2 inches and spaced approximately 15 inches apart are to be secured to the vertical surfaces of the chambers clear of air ducts, screens and cooler casings, and are to be fitted to suit the air flow. The outer edges of the battens are to be chamfered.

416 Cargo battens of not less than 3 inches × 3 inches are to be secured over the tunnel top insulation.

Stiffening of Insulation Linings and Air Ducts

417 Insulation linings and air screens on the sides of chambers are to be suitably stiffened to prevent crushing by cargo, in particular where ship sides are curved inwards and according to the nature of the cargo, whether general or refrigerated, which the Owners intend to carry in the chambers. Air duct sides or insulation linings which may have to support heavy loads are to be constructed to Owners' requirements.

Thermometers

418 Thermometers are to be of approved type, number and position in each chamber.

419 Thermometer tubes with their flanges and covers are to be insulated from the deck plating, and on weather decks they are to be so arranged that water will not run down the tubes when taking the temperatures.

420 The inside diameter of thermometer tubes is to be not less than 2 inches and the tubes are not to be in contact with cold decks.

421 Where thermometer tubes pass through compartments other than that which they serve, they are to be efficiently insulated.

Galvanizing of Fixtures

422 All steel bolts, nuts, hangers, brackets and fixtures which support or secure cooling appliances, insulation, meat rails, etc., are to be galvanized.

Section 5

TESTS AFTER COMPLETION

Thermometers

501 All thermometers provided for measuring chamber, air suction and air delivery temperatures are to be checked for accuracy by the contractors and a statement handed to the Surveyors. The Surveyors may use their discretion as to whether check tests are necessary.

Air Cooler Fan Outputs and Air Circulating Arrangements

502 Air cooler fans are to be tested by the contractors after the air circulating system has been completed and a statement of the results for each chamber handed to the Surveyors. The statement is to show the static pressure, the cubic feet of air circulated per minute, the fan speed and the power consumption. The air circulation arrangements in the chambers are to be checked for distribution.

Refrigeration Test

503 All plant is to be tested under working conditions.

Before the commencement of the test the Surveyors are to satisfy themselves that the electrical instruments, gauges and thermometers are accurate.

Where the minimum approved temperature required is the same in all chambers, or the difference is not greater than 5° F., the chambers are to be reduced in temperature simultaneously to not less than 2° F. below the lowest temperature required. As a minimum of 40° F. between the chamber and external temperatures is advisable it may be necessary to lower the chamber temperature further, but this should not be reduced below minus 20° F.

Where the temperature required in the separate chambers varies and the difference is greater than 5° F., each chamber is to be reduced in the manner described so that the normal temperature difference between the separate chambers is approximately maintained.

During the test the air cooler and air stirring fans are to operate at about maximum speed.

When the required temperatures have been attained, they are to be maintained constant by shutting down units and reducing the speed of the compressors remaining in continuous operation until the evaporating, condensing and brine (if used) temperatures and the speed of the compressor(s) are also steady, and this condition is to be maintained for a period of six hours, or longer if found necessary.

504 From the time the required temperatures have been attained, to the end of the test, all relevant temperatures and pressures are to be recorded at hourly intervals together with the speed and power consumption of the compressors and fan motors, and the power consumption of the brine and cooling water pumps.

505 Where an installation is to be completed and tested during a period when extremely low external temperatures are probable, and a reasonable difference between the chamber and external temperatures will not be possible without reducing the chamber temperatures below minus 20° F., or where the refrigerating machines are driven by constant speed motors, the case is to be submitted to the Committee for special consideration, and a test with the use of heaters may be required.

506 In cases where it is reasonable to believe that the refrigerating plant is inefficient an output test on the plant may also be required.

Air Cooler Defrosting Arrangements

507 The cooler defrosting arrangements are to be tested.

Section 6

SPARE GEAR

601 The following spare gear will be required in all cases:—

1 fan impeller of the propeller type of each size used.

1 set of the wearing parts of the crank shaft seals for each compressor where the crank case is subject to the refrigerant pressure.

1 set of crank shaft coupling bolts of each size used.

1 set of motor coupling bolts and washers, of each size used.

1 compressor piston with piston or connecting rod complete, of each size used.

1 complete assembly of each size of compressor suction and delivery valve.

1 complete set of packing for CO_2 compressor piston rod glands of each size used.

1 set of the working parts, together with packing and piston leathers, for the lubricating oil pump for CO_2 compressor rod glands.

1 gas regulator valve of each size used.

1 float regulator assembly of each size used.

1 set of suction and delivery valves for cooling water, air and brine pumps, of each size used.

1 set of driving belts of each size used.

Sundry lengths and bends of piping together with flanges, couplings and screwing appliances.

Sundry cocks, valves, flanges and fittings.

Assorted bolts, nuts, studs, packing and joint rings.

5 per cent. of the total number of electrical or tube thermometers, but not less than two of each.

Not less than two standard thermometers of the necessary temperature range.

1 spare battery for each electric thermometer indicator fitted.

1 hydrometer, where brine is the cooling medium.

1 halide lamp leak detector, where dichlorodifluoromethane or monochlorodifluoromethane is the refrigerant.

2 safety valve springs of each size used.

6 safety discs of each size used.

In cases where approval is given to alternative arrangements under N 104, additional spare gear may be required according to the circumstances of the case.

602 Where steam driven air circulating fans are fitted, the following spare gear will be required:—

For each size used:—

1 crank shaft.

1 steam piston and rod complete.

1 steam cylinder cover.

1 set of connecting rod top and bottom end bearing bushes, and bolts complete.

603 Where the refrigerating machines are direct driven by steam engines or by oil engines, the spare gear is to be in accordance with Chapter K.

604 Where any component of the refrigerating plant is electrically driven the spare gear is to be in accordance with M 2403, and in the case of fan motors, M 2405, except where a duplicate fan motor (*see* N 363) is installed ready for use.

605 It is assumed that the Owners will arrange for the necessary reserve supply of the refrigerant, calcium chloride and oils for the voyage intended.

Section 7

INSTALLATIONS NOT CONSTRUCTED UNDER SURVEY

701 When classification is desired for an installation not constructed under the supervision of the Society's Surveyors, application is to be made to the Committee in writing.

702 Full particulars and plans are to be forwarded for consideration, together with the particulars of the materials of the crankshafts, pressure vessels and pressure piping. The requirements of N 202 are to be used for guidance in regard to the information required.

703 A special examination is to be made at least to the extent required for Subsequent Special Surveys. (*See* N 860 to N 865.)

704 The thickness and material of the insulation, the particulars of the frames, beams, stiffeners and other steel work within the insulation, the air coolers and/or chamber grid piping, the compressors, evaporators and condensers are to be verified, and the particulars of the other components of the refrigerating plant are to be verified so far as practicable.

705 The installation is to conform with the requirements of N 3, N 4 and N 6, so far as applicable.

706 A test is to be carried out in accordance with N 503 to N 505, and air circulation arrangements in the chambers are to be checked for air distribution.

Section 8

PERIODICAL AND OTHER SURVEYS

Incidence of Surveys

801 For the retention of the class assigned installations are to be subjected to the periodical surveys specified in the following paragraphs.

802 Where desired by the Owners, the Intermediate and Running Surveys may be held at shorter intervals than those specified in 805 and 806, for a fresh record of Survey and the issue of a new Certificate.

803 A Loading Port Survey, as detailed in 814 to 818, is to be held at the loading port every voyage in the case of ships engaged on voyages of more than two months' duration, but where the voyages are of shorter duration, this survey need only be held at intervals of two months, provided that any general cargoes carried are of such a nature as not to damage the insulation or appliances in the insulated chambers nor to affect the refrigerated cargoes by taint or mould.

804 A Biennial Survey as detailed in 819 to 843, is to be held, the first 2 years after the date of the survey for Classification, and thereafter two years from the date of the previous Biennial Survey.

805 An Intermediate Survey as detailed in 844 to 846 is to be held about twelve months after the date of the survey for Classification and about twelve months after each Biennial Survey.

806 Running Surveys as detailed in 847 to 851 may be held, if desired by the Owners, at intervals not exceeding twelve months in lieu of the Intermediate and Biennial Surveys.

807 A Special Survey as detailed in 852 to 865, is to be held at 4-yearly intervals, the first 4 years after the date of the survey for Classification, and thereafter four years from the date of the previous Special Survey. The requirements of 856 to 859 of this survey should be carried out

whenever possible at the time of the Special Surveys prescribed in B 8, except in the case of small installations where major parts of the ship's structure are not involved.

A Special Survey will normally become due at the same time as a Biennial or a Running Survey, but when they do not coincide and the other Periodical Surveys are held within the specified intervals the requirements of 853 to 859 and 861 to 865 only, of the Special Survey will be necessary, but the date assigned to the Special Survey will be that of the Biennial or the Running Survey.

When it is inconvenient for Owners to fulfil the Special Survey requirements at the due date, the Committee will be prepared to consider its postponement, either wholly or in part, for a period not exceeding twelve months from the due date, provided the other Periodical Surveys continue to be held at the specified intervals.

Survey of Repairs

808 Where any essential repairs and/or renewals are effected to an installation, these are to be carried out under the supervision, and to the satisfaction, of the Society's Surveyors. Repairs and renewals effected at ports where there is no Surveyor to this Society are to be surveyed by one of the Society's Surveyors at the earliest opportunity.

Alterations and Additions

809 Plans and particulars of any proposed alterations or additions to the refrigerated cargo chambers or refrigerating plant are to be submitted for approval, and the work is to be carried out under the supervision and to the satisfaction of the Society's Surveyors.

Record of Surveys

810 The date following the class notation Lloyd's RMC on the certificate indicates the date of the last Biennial Survey thus:— Lloyd's RMC 2,54, and the date under this notation indicates the date of the last Intermediate Survey thus :—Lloyd's RMC $\frac{2,54}{12,54}$. These dates will be recorded in the appropriate columns of the Supplement to the Register Book.

811 When Running Surveys are held in lieu of Biennial and Intermediate Surveys this will be indicated by the class notation Lloyd's RMC (RS) (with date). This date will be recorded in the appropriate column of the Supplement to the Register Book.

812 The date of the last Special Survey will be indicated by the notation SRMC (with date). This date will be recorded in the appropriate column in the Appendix to the Register Book and the Supplement.

Notice of Surveys

813 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Periodical Surveys of Refrigerated Cargo Installations become due, but the non-receipt of such notice does not absolve Owners from this responsibility.

Loading Port Surveys

814 The chambers are to be examined in an empty state to ascertain that they are clean and free from odour which may adversely affect the cargo to be loaded, that the brine or other refrigerant pipe grids, cooler coils and connections are free from leakage, that the fixed cargo battens on the vertical surfaces are in good order, that cargo gratings or dunnage battens are provided for the floors or decks as required to suit the class of cargo, and that no damage has been sustained to the insulation or its lining prior to the loading of the refrigerated cargo. Any indications of defective insulation not considered to warrant immediate attention should be noted and specially reported.

815 The Surveyor is to satisfy himself that all scuppers and bilge suctions draining insulated spaces are in good working order, and that the liquid seals are primed.

816 The refrigerating installation is to be examined under working conditions, and the temperatures in the cargo chambers are to be noted.

817 If the ship loads at more than one port, one survey only at the first loading port will be required, provided it includes the examination of all the chambers which are to be used for refrigerated cargo during the voyage and general cargo is not subsequently carried in any of the chambers prior to loading the refrigerated cargo.

818 If there is no Surveyor to the Society available at the loading port(s), or if there is none obtainable from a port within a reasonable distance, the Committee will accept the report of a survey held at the loading port by a surveyor appointed by Lloyd's Agent; or in any case where there is no Lloyd's Agent, the report of a survey held by a reliable surveyor, if available; if no such surveyor is available, a report signed by two competent engineers of the ship will be accepted.

Biennial Surveys

819 Whenever possible the machinery in use is to be examined under working conditions on the ship's arrival at

the port of discharge before the refrigerated cargo is unloaded, irrespective of whether any further part of the survey is to be held at the port.

820 The entries in the ship's refrigeration logbook are to be examined in order to ascertain whether the performance of the installation has been satisfactory during the voyage. Breakdowns, irregularities in the working of the plant, or the too frequent or lengthy defrosting of air coolers, are to be noted and reported. This requirement may be carried out after the completion of the discharge before the examination of the cargo chambers.

When refrigerated cargo has not been carried during the voyage immediately prior to the survey the last records are to be examined.

821 Should the entries in the logbook show that the load on the plant is generally above the normal for the duty involved during the voyage, steps are to be taken to determine the cause and have it dealt with as found necessary.

822 The cargo chambers are to be examined for condition throughout, with the bilge and manhole plugs removed in the lower holds. Any indication of dampness or leakage into the insulation from tanks, piping within the insulation, scuppers, decks, hatchways or other sources, or of deterioration of attachments and supports of insulation and linings, air ducts, grids or meat rails, is to be investigated and any such defects rectified.

823 Where no air space is provided below the insulation on tank tops and there is no effective means of detecting leakages into the insulation, the floor covering is to be drilled and the insulation tested. Tank and tunnel top insulation in way of hatchways is to be similarly tested where dampness is evident.

824 Where chambers are cooled by forced air circulation and parts of insulation linings or air ducts are removed or repaired, care is to be taken that all joints are sealed to prevent air blowing into the insulation.

825 Air ducts, air cooler casings, insulation linings and protrusions through the linings are to be examined as far as practicable for condition, and special attention is to be given to the prevention of air blowing into the insulation. Where asphalt or similar material is used for floor covering, the junction with the insulation lining is to be examined for shrinkage which may cause air leakage into the insulation.

826 Where there is no evidence in the logbook of an abnormal load on the plant or on individual coolers or chamber grids, and there is no visible indication of insulation defects, the removal of parts of air ducts and insulation linings, and the drilling of linings is not required on vertical and overhead surfaces of chambers cooled by forced air circulation. The Surveyor should use his discretion as to whether the linings on these surfaces should be drilled in grid-cooled chambers having regard to the nature of the insulation and the material with which it is lined.

827 All test holes are to be effectively closed.

828 Hatch plugs and supports, chamber and access doors and their frames, air refreshing pipe and ventilator closing appliances, bilge and manhole plugs are to be examined for condition and airtightness. Thermometer tubes, their connections and fastenings are to be examined.

829 The bilges are to be cleaned; suction pipes, suction roses, sounding pipes and scupper non-return valves are to be examined. The Surveyor is to satisfy himself that all scuppers draining the chambers and air cooler trays are in good working order.

830 Cooling grids, air cooler coils, cooler trays and fans are to be examined. The Surveyor is to satisfy himself that sections of cooler coils or grids are not choked or partially choked.

831 Brine or water refrigerant pipe grids and cooler coils are to be tested to $1\frac{1}{2}$ times the working pressure or 40 lb. per square inch, whichever is the greater.

832 Primary refrigerant pipe grids and cooler coils with their valves and connections are to be examined whilst under the refrigerant pressure prevailing in the system at the time of the survey, with the plant at rest and the regulating valves opened sufficiently to obtain an approximate balance of pressure throughout the system.

833 The insulation of pipes carrying the refrigerating medium (service pipes, mains, leads and returns) between the chambers and the plant and/or control rooms are to be examined.

834 Where the refrigerating machinery or its auxiliaries are electrically driven a general examination of all the motors and their control gear and cables is to be made and the insulation resistance measured. The insulation resistance is to be not less than 100,000 Ohms, and for the purpose of this test, each item may be taken separately. Where the Owners employ competent and reliable staff or an electrical contractor, the Surveyor may consult their records and, at his discretion, accept megger tests carried out by them.

Generating plant supplying electric power to the refrigerating machinery is to be examined generally, including the plant in operation. The ship's records of examination, overhaul and repair are to be sighted; if no records are available, the ship's personnel are to be consulted in regard thereto. Any part of the plant is to be opened up for examination which the Surveyor may consider necessary. In the case of ships which are not classed with the Society, the Surveyor is also to ascertain that periodical examinations of the working parts continue to be held by the Classification Society concerned.

835 The primary refrigerant gas and liquid pipes, separators, receivers, driers, filters, condenser and evaporator coil terminals of the "coil in casing" type, and the shells of the "shell and tube" type, heat exchangers and all other pressure parts of the system are to be examined externally so far as practicable.

836 The refrigerating plant spare gear is to be examined.

837 A reasonable percentage of the thermometers used for measuring chamber or air suction and delivery temperatures are to be checked at each survey. Each thermometer is to be checked at intervals not exceeding four years. The Surveyor may, at his discretion, accept the results of thermometer tests carried out by competent staff or by a contractor employed by the Owners.

838 The water end covers of "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined.

839 All reciprocating refrigerating machines including those provided for primary refrigerant liquid cooling are to be opened up; the cylinders, valves and seats, crankshafts, connecting rods, pistons and piston rods, and all bearings are to be examined. The lower halves of main bearings need not necessarily be exposed if the Surveyor is satisfied with the alignment and wear. The lubricating arrangements are also to be examined.

840 Where the refrigerating machinery is driven by steam or internal combustion engines, all the working parts of the engines are to be opened up and examined, including all pumps directly driven by the driving engines, in a similar manner to that specified for the refrigerating machines (*see* 839).

Steam condensers exclusive to the refrigerating plant driving engines are also to be examined and, if considered necessary, they are to be tested.

841 The working parts of all independent gas condenser cooling and brine circulating pumps are to be examined. Where the standby condenser cooling pump is one of the pumps used for other purposes, this pump is also to be examined.

842 In the case of steam jet vacuum refrigerating plants, which provide the cooling medium circulated through the chamber cooling appliances, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, the condenser cooling, the condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

843 At intervals of 6 years from the date of construction, the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined and those pipes over 3 inches internal diameter are to be included in the survey required by C 9.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 9.

Intermediate Surveys

844 All the requirements of 819 to 837 (Biennial Survey) are to be complied with.

845 The water end covers of one of the "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined; if the Surveyor considers it necessary the other condensers of the same type are to be similarly treated.

846 The whole of the plant referred to in 839 to 842 is to be generally examined and any part is to be opened up for examination which the Surveyor may consider necessary. Any component opened up for overhaul at the time of the survey is also to be examined.

Running Surveys

847 All the requirements of 819 to 837 (Biennial Survey) and 845 to 846 (Intermediate Survey) are to be complied with.

848 The tubes and tube plates of each "shell and tube" type gas condenser are to be examined at intervals not exceeding two years.

849 The plant referred to in 839 to 842 (Biennial Survey) is to be opened up and examined in rotation so that the whole of the plant is examined within each period of two years, but one of the main refrigerating machines and, where applicable, its steam or internal combustion driving engine, one of the condenser cooling pumps and, where applicable, one of the brine circulating pumps, are to be examined either at each survey or within the previous six months.

In the case of steam jet vacuum refrigerating plants which provide the cooling medium circulated through the chamber cooling appliances, one of the flash chambers with its water spray arrangements, one of the thermo-compressor steam chambers and nozzles, one of the condenser cooling water pumps and one of the cooled water circulating pumps are to be examined either at each survey or within the previous six months.

850 *A survey book is to be kept on board the ship to show the date of examination of the various parts, and is to be signed by the Surveyor on the occasion of each survey.*

851 At intervals of six years from the date of construction the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined, and those pipes over 3 inches internal diameter are to be included in the survey required by C 9.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 9.

First Special Survey

852 All the requirements of 819 to 843 (Biennial Survey) are to be complied with except where the surveys are being held in accordance with 806, when the requirements of 847 to 851 (Running Survey) are to be complied with.

853 Where the refrigerating machinery is driven by internal combustion engines and independent air compressors and air receivers exclusive to the refrigerating plant are installed, the working parts of the compressors and their intercoolers and safety devices are to be examined. The air receivers with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

854 The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the refrigerating plant are in good order. No attempt, however, should be made to test primary refrigerant pressure relief valves on board ship.

855 In the case of steam jet vacuum refrigerating plants installed for sub-cooling the primary refrigerant liquid, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, condenser cooling and condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

856 Sufficient insulation is to be stripped from pipes carrying the refrigerating medium at various points of the system particularly in bunkers or near boilers, on decks or where buried in hold insulation, to permit of the condition of the pipes being ascertained. Care is to be taken that on replacement the seal of the outer covering over the insulation is made good where the pipes are exposed to atmospheric conditions, particularly in bunkers, in accordance with N 412.

857 Sufficient air trunking and insulation lining is to be stripped from the chamber overhead and vertical surfaces to permit of the condition of the insulation, insulation linings, grounds, supports, hangers and fixtures which support the insulation, grids, meat rails, etc., being ascertained. Care is to be taken that on replacement the ducts and linings are sealed against air blowing into the insulation.

858 Sufficient tank top insulation is to be stripped to permit of the condition of the grounds and inner insulation lining being ascertained.

859 Sea connections to condenser cooling water pumps are to be opened up and examined.

Subsequent Special Surveys

860 All the requirements of 852 to 859 (First Special Survey) are to be complied with.

861 The coils of gas condensers and evaporators (brine coolers) of the "coil-in-casing" type are to be drawn for examination where this is reasonably practicable. In the case of condensers and evaporators which are unwieldy or where there is insufficient head room, an examination of the coils is to be made in place, through the openings in the casings.

The coils of the condensers are to be tested to a pressure of 250 lb. per square inch for methyl chloride or dichlorodifluoromethane systems, 1000 lb. per square inch for ammonia and monochlorodifluoromethane systems and 2,000 lb. per square inch for carbon dioxide systems.

The coils of the evaporators are to be tested to a pressure of 200 lb. per square inch for methyl chloride or dichlorodifluoromethane systems, 500 lb. per square inch for ammonia and monochlorodifluoromethane systems and 1,500 lb. per square inch for carbon dioxide systems.

862 Gas condensers of the "shell and tube" type are to have the water or brine end covers removed and are to be tested to a pressure of 250 lb. per square inch for methyl chloride or dichlorodifluoromethane systems, and 400 lb. per square inch for ammonia and monochlorodifluoromethane systems.

Gas evaporators (brine coolers) of the "shell and tube" type are to have the brine end covers removed and are to be tested to a pressure of 200 lb. per square inch for methyl chloride or dichlorodifluoromethane systems and 300 lb. per square inch for ammonia and monochlorodifluoromethane systems.

863 Primary refrigerant liquid sub-cooling coils in flash chambers of steam jet vacuum refrigerating plants are to be examined and tested to the same pressure as that required for condensers in 861.

864 Where brine or water is used for sub-cooling the primary refrigerant liquid in heat exchangers of the "shell and tube" type, the heat exchangers are to be examined and tested in the same manner as that required for condensers in 862.

"Double pipe" type heat exchangers are to be examined so far as practicable with the gas piping under the same pressures as that required for condensers in 862 and the water or brine from the outlets is to be tested for gas leakage.

Other type of heat exchangers using brine or water are to be examined and tested at the discretion of the Surveyor according to the design of such equipment.

865 Primary refrigerant chamber grids or air cooled coils are to be tested in place to a pressure of 100 lb. per square inch for methyl chloride or dichlorodifluoromethane, 150 lb. per square inch for ammonia or monochlorodifluoromethane systems, and 1,000 lb. per square inch for carbon dioxide systems.

Section 9

PORTABLE REFRIGERATED CARGO CONTAINERS

General

901 Portable refrigerated cargo containers intended to be carried on the Owners' ships, and loaded and discharged on board, which comply with N 1 to N 8, in so far as they are applicable, except as provided in the following paragraphs will be included in the installations covered by B 901 and B 902.

902 The Shipowners' name and an identification number are to be clearly marked on each container. It is also to be indicated on the container that it is not to be lifted in a loaded condition.

903 A log book showing the particulars of the refrigeration of the container during each voyage is to be maintained, and this is to be made available to the Surveyor at each of the surveys required by 917.

Where the plant is operated by thermostatic control the intervals during which the machinery is working and at rest should be recorded occasionally, particularly during the period of maximum external temperature conditions of each voyage.

Class Notation

904 The class notation will be in accordance with N 1 except that where the refrigerant condenser is air cooled the class notation shown in N 101 will give the maximum ambient temperature instead of the maximum sea temperature, e.g., "to maintain temp. 10° F. with ambient temp. 104° F. maximum".

Where the refrigerating machinery is electrically driven and dependent on the ship's generators for power, the class assigned will be subject to suitable electric power being available at all times when the container is loaded with refrigerated cargo.

Special Survey during Construction

905 The requirements of N 2 are to be complied with in so far as they are applicable.

Refrigerating Plant

906 The requirements of N 3 are to be complied with in so far as they are applicable, except as modified by 907 to 909.

907 Where the refrigerant condenser is air cooled and the maximum gas discharge pressure is above the maxima specified in N 326 and N 330, the design pressure is to be correspondingly increased.

908 Where the design pressure is increased in accordance with 907, the test pressures specified in N 339 are to be increased proportionately.

909 Where "shell and tube" type evaporators (brine coolers) and condensers can be readily removed, the space for the withdrawal and renewal of tubes in accordance with N 348 will not be required.

Cargo Space

910 The external structure, including the door, is to be of robust design and constructed of, or covered with, water vapour resisting materials, and the joints are to be effectively sealed. The structure is to be carefully examined for tightness before the insulation is applied. The access door is to be airtight when closed.

911 The containers are to comply with the requirements of N 404 and N 405, N 407 and N 408, N 414 and N 415, N 417 and N 422 in so far as they are applicable.

912 Drains of not less than $\frac{3}{4}$ inch bore are to be provided from the cargo space and air cooler trays, and the drains are to be fitted with means of closure operable from outside the cargo space.

913 Thermometers are to be of approved type and position in the cargo space. Where thermometer tubes are provided the method of attachment is also to be approved.

Tests after Completion

914 The requirements of N 5 are to be complied with in so far as they are applicable.

Spare Gear

915 The spare gear is to be in accordance with N 6 in so far as that Section is applicable.

Containers not Constructed under Survey

916 The requirements of N 7 are to be complied with in so far as they are applicable, except as amended by this Section.

Periodical and other Surveys

917 For the retention of the class assigned periodical and other Surveys are to be carried out in accordance with N 8 except as modified in the following paragraphs.

Loading Port Surveys

918 The requirements of N 814 and N 816 are to be complied with and, in addition, the Surveyor is to satisfy himself that the container is placed on board in such a position as to provide free access to the container by the ship's personnel for servicing the refrigerating plant and noting the temperatures; and, where the refrigerant condenser is air cooled, to allow free flow of fresh air to, and heated air from, the condenser.

919 Generating plant supplying power and the cables and connections to the refrigerating machinery are to be examined generally.

920 The Surveyor is also to satisfy himself that the drains from the cargo space and air cooler trays are clear and the closing devices are in order.

Biennial Surveys

921 All the requirements of N 819 to N 828, and N 830 to N 841, except the second paragraph of N 834, are to be complied with in so far as they are applicable.

922 The cargo space and air cooler tray drains and their closing devices are to be examined.

Intermediate Surveys

923 All the requirements of N 819 to N 828 and N 830 to N 837, except the second paragraph of N 834, and those of N 845 and N 846, and 922 are to be complied with in so far as they are applicable.

Running Surveys

924 All the requirements of N 819 to N 828 and N 830 to N 837, except the second paragraph of N 834, and those of N 845 and N 846, N 848 to N 850, and 922 are to be complied with in so far as they are applicable.

925 Where one refrigerating unit only is installed the Running Survey system cannot be adopted.

First Special Survey

926 All the requirements of N 853 to N 857 in so far as they are applicable and, in addition, those of 921 and 922 (Biennial Surveys) or, where the surveys are being held in accordance with N 806, those of 924 (Running Surveys), are to be complied with.

927 Sufficient covering and insulation is to be stripped from the floor of the container to permit of the condition of the insulation, grounds and structure being ascertained.

Subsequent Special Surveys

928 All the requirements of N 861 to N 865, in so far as they are applicable, and, in addition, those of 926 and 927 are to be complied with.

21st July, 1955.

Chapter P

QUALITY AND TESTING OF MATERIALS

Note:— For list of steel manufacturers see Appendix to this Chapter

Section 1

SHIP AND BOILER STEEL

General Regulations

101 The steel used in the construction of ships or boilers intended for ships classed, or proposed for classification, in the Society's Register Book, is to comply with the tests described hereafter.

Process of Manufacture

102 The steel is to be made by the open hearth, electric furnace, or other approved process.

Freedom from Defects

103 The finished material is to be free from cracks, surface flaws, and lamination. It is also to have a workmanlike finish, and must not have been hammer-dressed.

Testing and Inspection

104 The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any of the material proving unsatisfactory in the course of being worked into ships or into boilers, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same charge may be made as the Surveyor may consider desirable.

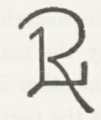
105 All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

Additional Tests before Rejection

106 Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, two further tests of the same kind may be made from the same plate or bar, but where either of these fail, the plate or bar from which the test pieces were cut is to be rejected. In all such cases further tests are to be made before any material from the same charge can be accepted.

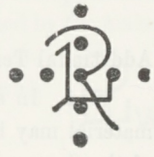
107 Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the maker's option, be discarded and another test be made of the same plate or bar.

Branding

108 Every plate and bar is to be clearly and distinctly marked by the maker in two places with the Society's brand, thus:—  indicating that the material has complied with the Society's tests.

109 Plates or bars bearing this brand are not to be forwarded from the steel works until the prescribed tests have been made by the Surveyor, and the mill sheets have been signed by him. All plates and bars are also to be legibly stamped in two places with the maker's name or trade mark, and the place where made. They are also to be stamped with numbers or identification marks by which they can be traced to the charge from which the material was made.

Defacing of Rejected Material

110 In the event of the material failing, in any case, to withstand the prescribed tests, the Surveyor is to see that the Society's brand stamped on the plates and bars by the maker has been defaced by punch marks extending beyond the brand in the form of a cross, thus :—  denoting that the material has been rejected.

Maker's Certificate

111 Before the mill sheets are signed by the Surveyor the maker is required to furnish him with a certificate guaranteeing that the material has been made by an approved process, and that it has been subjected to, and has withstood satisfactorily, the required tests in the presence of

the Surveyor. The following form of certificate will be accepted if printed on each mill sheet with the name of the firm, and initialled by the test house manager :—

> "We hereby certify that the material described below has been made by an approved process, and in accordance with the Rules of Lloyd's Register and is that which has been satisfactorily tested in the presence of the Surveyor."

Facilities for Inspection

112 The maker is to adopt a system of marking the ingots, billets, slabs, plates, bars, and other material which will enable all finished material to be traced to the original charge, and the Surveyor must be given every facility for tracing all plates and bars to their respective charges, and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of the tests, he is to be furnished with two copies of the advice notes of the material for his signature, one of which is to be forwarded by the manufacturer to the shipbuilder or boiler maker, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship or boiler is to be built.

Steel not Produced where Rolled

113 Where steel is not produced in the works at which it is rolled, a certificate is to be supplied to the Surveyor, stating the open hearth process by which it was made, the name of the steel maker who supplied it, also the numbers of the charges for reference to the books of the steel maker. The number of the charge is to be marked on each ingot or billet for the purpose of identification, and the finished plates and bars are also to be legibly stamped in two places with the maker's name or trade mark, and the place where made. They are also to be stamped with numbers or identification marks by which they can be traced to the charge from which the material was made.

Additional Tests

114 In addition to the tests described hereafter the material may be subjected to further tests at the discretion of the Surveyors.

Alternative Proposals

115 The Committee will be prepared to consider proposals for the use of steel having properties different from those prescribed in the Rules, provided full particulars of the properties and manufacture of the material are submitted for consideration.

Section 2

STANDARD TENSILE TEST PIECES

General

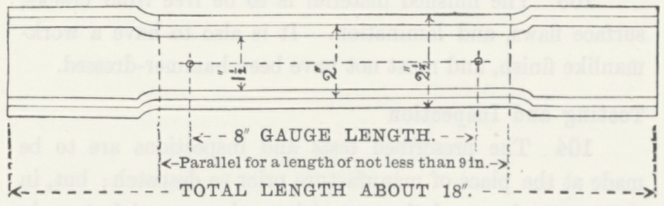
201 The tensile strength and ductility are to be determined from standard test pieces cut lengthwise or crosswise from the rolled material. Where material is annealed or otherwise treated before despatch, the test pieces are to be similarly and simultaneously treated with the material before testing.

Plates

202 Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test piece. The elongation is to be measured on a standard test piece having a gauge length of 8 inches.

203 For material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed $1\frac{1}{2}$ inches; for material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exceed 2 inches; for material less than ·375 inch in thickness the width is not to exceed $2\frac{1}{2}$ inches. In other respects the test pieces are to conform generally to the standard test piece A.

TEST PIECE A



For Thicknesses over ·875":—Maximum width allowed=$1\frac{1}{2}$".

For Thicknesses ·375" to ·875":—Maximum width allowed=2".

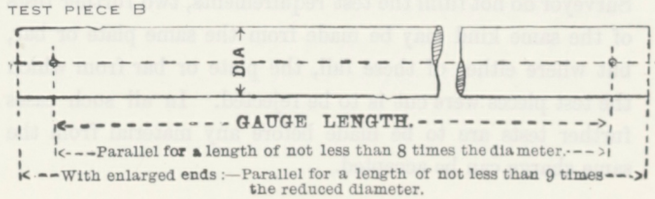
For Thicknesses under ·375":—Maximum width allowed=$2\frac{1}{2}$".

Round Bars

204 Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested 1 inch in diameter, or under, the test piece is to have a gauge length of eight times the diameter. Where enlarged ends are used, the length of the parallel portion is not to be less than nine times the reduced diameter of the test piece (*see* standard test piece B).

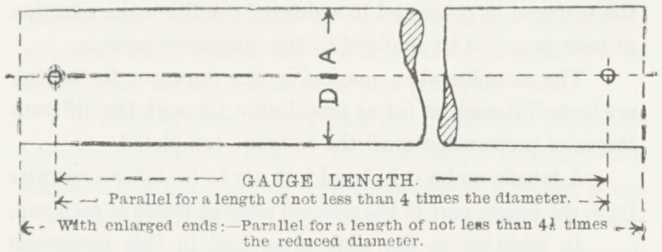
The sectional area of the test piece is not to be less than $\frac{1}{4}$ square inch.

TEST PIECE B



205 Where bars are above 1 inch diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch diameter, a gauge length of four times the diameter may be used if preferred by the manufacturer, in which case an increased elongation will be required, as specified in P 5 and P 6. Where enlarged ends are used, the length of the parallel portion is not to be less than 4·5 times the reduced diameter of the test piece (*see* standard test piece C).

TEST PIECE C



Straightening of Test Pieces

206 Any straightening of test pieces A, B and C which may be required is to be done cold.

Section 3

BEND TESTS FOR SHIP AND BOILER STEEL

Number of Bend Tests for Ship Steel

301 A bend test is to be taken from each plate as rolled.

One bend test is to be made from each type of section and from each diameter of bar in every batch of 5 tons or part of 5 tons rolled from the same charge with a minimum of two bend tests per batch.

Number of Bend Tests for Boiler Steel

302 PLATES.—A bend test piece is to be taken from each plate as rolled. For plates exceeding $2\frac{1}{2}$ tons in weight one bend test piece is to be taken from each end.

303 ANGLE BARS.—A bend test is to be taken from each angle bar rolled.

304 STAY BARS.—A bend test is to be made where a tensile test is required.

Bend Test Pieces

305 Test pieces are to be sheared lengthwise or crosswise from plates or bars, and are not to be less than $1\frac{1}{2}$ inches wide, but for small bars the whole section may be used. For rivet bars bend tests are not required.

306 In all bend tests, the rough edge or arris caused by shearing may be removed by filing or grinding, and test pieces 1 inch in thickness and above may have the edges machined, but the test pieces are to receive no other preparation. The test pieces are not to be annealed or otherwise heat treated unless the material from which they are cut is similarly heat treated, in which case the test pieces are to be similarly and simultaneously treated with the material before testing.

307 For small sectional material these bend tests may be made from the flattened bar.

Bend Tests

308 The test piece is to withstand, without fracture, being doubled over until the internal radius is equal to 1·5 times the thickness of the test piece, and the sides are parallel.

The bending may be performed either by pressure or by blows.

Section 4

SHIP STEEL

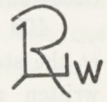
Specification

401 The steel is to contain not more than ·06 per cent of sulphur or ·06 per cent phosphorus.

402 For plates having a thickness greater than $\frac{1}{2}$ inch the manganese content is to be not less than 2·5 times the carbon content.

403 When the main structure of a ship is intended to be wholly or partially welded, the Committee may require parts of primary structural importance to be of steel, the properties and process of manufacture of which have been specially approved for this purpose (*see* D4004).

Every plate and bar of such material, irrespective of thickness, is to be clearly and distinctly marked by the maker in two places with the Society's brand thus :— indicating that the material has complied with the Society's tests.



404 The chemical contents referred to in 401 and 402 are to be determined from ladle analyses.

Number of Tensile Tests

405 When the Surveyor is in constant attendance at the steel works one tensile test piece for plates or sectional material is to be taken from the finished material of each charge.

Where the quantity of the material from one charge exceeds 25 tons, a second tensile test will be required. Additional tests are to be made for every variation in thickness of ·15 of an inch in the plates or sectional bars from each charge.

Tensile Tests

406 PLATES.—The tensile breaking strength of steel plates, determined from standard test pieces, is to be between the limits of 26 and 32 tons per square inch. For plates specially intended for cold flanging and marked for identification, the tensile strength is to be between the limits of 26 and 30 tons per square inch. In the case of material for purposes in which tensile strength is not important, the tensile test may be dispensed with and the bend test only be made, if so specified by the builders and approved by the Committee. The elongation, measured on a standard test piece having a gauge length of 8 inches, is not to be less than 20 per cent for material of ·375 inch in thickness and upwards, and not less than 16 per cent for material below ·375 inch in thickness.

407 ANGLES, BULB ANGLES, CHANNELS, AND SIMILAR SECTIONS.—The tensile breaking strength of angles, bulb angles, channels, and similar sectional material is to be between the limits of 26 and 32 tons per square inch. In the case of material for purposes in which tensile strength is not important, the tensile test may be dispensed with and the bend test only be made, if so specified by the builders and approved by the Committee. The elongation, measured on a standard test piece having a gauge length of 8 inches, is not to be less than 20 per cent for material of ·375 inch in thickness and upwards, and not less than 16 per cent for material below ·375 inch in thickness.

Cross-references

408 For bend tests for shipbuilding steel *see* P 3.

For testing of special quality ship steel *see* P 7.

Occasional Attendance at Steel Works

409 When the Surveyor is not in constant attendance at the steel works, the makers themselves may, with the written authority of the Society, comply with all the prescribed requirements, and furnish the Surveyor with a certificate to the effect that the Society's Rules as to the testing of steel have been complied with in the case of the material submitted for approval.

The Surveyor is then to make check tensile and cold bend tests from not less than one bar in every batch of 50 or less in number, or not less than one plate in each batch of 25 or less in number, provided the batch be all from one charge.

Where more than one charge is represented, each charge is to be tested.

Additional tests are also to be made for every variation in thickness of ·15 of an inch made from one charge.

The test pieces are not to be taken from shearings previously detached from the plates or bars but are to be selected by the Surveyors from the plates or bars themselves, either in the sheared or unsheared condition. Should part of the material be presented in a sheared condition the selection of tests is not to be confined to the unsheared portion.

The samples when marked by the Surveyor for testing are to be followed, as far as practicable, through the different stages of preparation until the tests are completed.

A tensile and a cold bend test are to be taken crosswise from the centre part of the selected plate or plates at each end.

In addition to the tests prescribed in this paragraph the material may be subjected to further tests at the discretion of the Surveyor.

410 Where the tests are unsatisfactory, the whole of the material from the charge is to be rejected, and the Surveyor is to see that the Society's brand is satisfactorily defaced.

Section 5

STEEL FOR BOILERS AND OTHER PRESSURE VESSELS

Heat Treatment

501 All plates intended for cylindrical shells where the thickness exceeds $1\frac{3}{4}$ inches should be efficiently normalised before the test pieces are cut off.

Number of Tensile Tests

502 PLATES.—One tensile test piece is to be taken from each plate as rolled. For plates exceeding $2\frac{1}{2}$ tons in weight one tensile test piece is to be taken from each end.

503 ANGLE, TEE AND STAY BARS.—One tensile test is to be made from each 15 or part of 15 bars rolled of each section or diameter from the same charge, but not less than two tensile tests are to be made, unless the total number of bars rolled from the same charge is 8 or less than 8 and the bars are of the same section or diameter, in which case one tensile test will suffice. For round bars of $1\frac{3}{4}$ inch diameter and under, the numbers 50 and 20 are to be substituted for 15 and 8 respectively in determining the number of tests required.

Tensile Tests

504 PLATES.—The tensile breaking strength of steel shell plates, determined from standard test pieces, is to be between the limits of 28 and 35 tons per square inch for riveted boilers, 26 and 35 tons per square inch for fusion welded pressure vessels and 26 and 30 tons per square inch for forge welded pressure vessels. *See also* 507.

For girder plates the tensile breaking strength is to be between the limits of 28 and 35 tons per square inch.

For plates intended for flanging and for combustion chambers and furnaces, also for plates, other than shell plates, which are to be welded, the tensile breaking strength is to be between the limits of 26 and 30 tons per square inch.

A range of more than 4 tons per square inch will not be permitted in any one case. The elongation, measured on a standard test piece having a gauge length of 8 inches, is not to be less than 20 per cent for material of ·375 inch in thickness and upwards required to have a tensile breaking strength between the limits of 28 and 35 tons per square inch ; and not less than 23 per cent for material of ·375 inch in thickness and upwards required to have a tensile breaking strength between the limits of 26 and 30 tons per square inch.

For plates under ·375 inch in thickness the elongation may be 3 per cent, but not more than 3 per cent, below the prescribed elongations.

505 ANGLE AND TEE BARS.—The tensile breaking strength of angle and tee bars is to be between the limits of 28 and 32 tons per square inch, with an elongation of not less than 20 per cent measured on the standard test piece A.

For angles or tee bars under ·375 inch in thickness the elongation may be 3 per cent, but not more than 3 per cent, below the prescribed elongations.

Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test pieces.

506 STAY BARS.—The tensile breaking strength of longitudinal stay bars is to be between the limits of 28 and 35 tons per square inch, with an elongation of not less than 20 per cent measured on the standard test piece B, or 24 per cent measured on the standard test piece C ; but a range of not more than 4 tons per square inch shall be permitted in any one case. For steel bars for combustion chamber stays the tensile breaking strength is to be between the limits of 26 and 30 tons per square inch, with an elongation of not less than 23 per cent measured on the standard test piece B or 28 per cent measured on the standard test piece C.

Special Quality Steel for Boilers

507 When steel material is proposed having tensile strength other than that specified in this Section, the proposed limits of tensile strength and elongation should be submitted for consideration.

In the case of forge welded cylindrical shells, material having tensile breaking strength between the limits of 24 and 28 tons per square inch, and elongation not less than 25 per cent on a gauge length of 8 inches will be accepted, the test pieces being taken crosswise from the plates as rolled.

Seamless Receivers

508 In the case of seamless receivers, the rules for material will be the same as for boiler shells, but the permissible extension may be 2 per cent less than that required for boiler plates.

The thicknesses of seamless receivers are to be verified by the Surveyor before the ends are closed in, and at this time the Surveyor is to select and mark the test pieces required from either of the open ends of the tube.

The test pieces are to be subjected to the same heat treatment as that given to the receivers.

Cross-reference

509 For bend tests *see* P 3.

Section 6

RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

601 All material from which rivets are manufactured is to be tested.

Rivets are not to be manufactured from steel or ingot iron bars in which the sulphur segregates and other non-metallic substances are concentrated in the core. To ensure this, a sulphur print is to be taken from the material of each charge, and where the weight of bars as rolled from one charge exceeds 10 tons, additional sulphur prints may be taken.

Number of Tests

602 In the case of steel bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

603 In the case of wrought iron bars, two tensile tests shall be taken from every 3 tons or portion thereof in each batch of any order presented for inspection, except that, in the case of lots of 1 ton or less, one tensile test shall be accepted.

604 In the case of ingot iron bars, one tensile test piece is to be taken from each charge used for rivet bars; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

605 For rivet bars of steel or ingot iron one dump test is to be made for each tensile test.

Tensile Tests

606 The tensile breaking strength of steel rivet bars is to be between the limits of 26 and 30 tons per square inch of section with an elongation of not less than 25 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B, or 30 per cent measured on the standard test piece C. The bars may be tested the full size as rolled.

607 The tensile breaking strength of wrought iron rivet bars is to be between the limits of 21 and 25 tons per square inch. The elongation is to be not less than 22 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B.

608 The tensile breaking strength of ingot iron rivet bars is to be between the limits of 21 and 25 tons per square inch, with an elongation of not less than 25 per cent of the gauge length of eight times the diameter of the test piece, measured on the standard test piece B, or 30 per cent measured on the standard test piece C. The bars may be tested the full size as rolled.

Dump Test

609 Short lengths, equal to twice their diameter, cut from the rivet bars shall, when cold, withstand without fracture being compressed to half their length.

Nicked Bend Tests

610 In the case of wrought iron bars one nicked bend test shall be taken from each 3 tons of material or portion thereof in each batch of any order presented for inspection.

611 The test pieces shall be lightly and evenly nicked on one side with a sharp cutting tool, and bent back at this point through an angle of 180 degrees. They shall show a clean fibrous fracture, free from slag or dirt or any coarse crystalline structure.

Manufactured Rivets

612 Rivets selected by the Surveyor from the bulk are to withstand the tests described in 613 to 615.

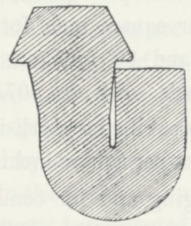


FIG. 1

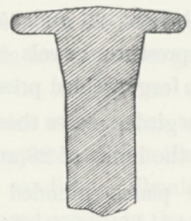


FIG. 2

613 The rivet shanks are to be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

614 The rivet heads are to be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The heads are to be flattened until their diameter is 2·5 times the diameter of the shank.

615 In the case of steel or ingot iron rivets, samples are to be selected by the Surveyor for examination by means of sulphur prints, to ensure that the material is free from marked central segregation.

Section 7

SPECIAL QUALITY SHIP STEEL

Process of Manufacture

701 The steel is to be made by the open hearth process, acid or basic, at works recognised by the Committee.

Freedom from Defects

702 The finished material is to be free from cracks, surface flaws and laminations. It is also to have a workmanlike finish, and must not be hammer dressed.

Testing and Inspection

703 The prescribed tests and inspections are to be made at the place of manufacture from the plates or bars in the condition in which they will be despatched; in the event of any of the material proving unsatisfactory in the course of being worked into the ships, such material shall be rejected, notwithstanding any previous certificate of satisfactory

testing, and such further tests of the material from the same charge may be made as the Surveyor may consider desirable.

All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

Tensile Test Pieces

704 The tensile strength, ductility and limit of proportionality, as defined in 706 and 707, are to be determined from standard test pieces cut lengthwise from the bar, and 50 per cent lengthwise and 50 per cent crosswise from the plate.

Where material is annealed or otherwise treated before despatch, the test pieces are not to be cut off until the annealing or treating process has been completed.

Standard Test Pieces

705 The test pieces are all to be of standard form as described in P 2.

Tensile Strength

706 The tensile breaking strength is not to exceed 38 tons per square inch, with a range of not more than 5 tons per square inch in any one case ; the elongation is to be not less than 20 per cent measured on a gauge length of 8 inches.

Limit of Proportionality

707 The material is to have a limit of proportionality of not less than 15 tons per square inch, the elastic properties being determined by means of a Ewing or other approved extensometer of 8 inch gauge length. The tests shall be carried out as follows :—

A load of 2 tons per square inch of section shall be applied to the test piece and an extensometer reading taken.

The load shall be increased to 15 tons per square inch of section and a second reading taken.

The load shall be reduced to 2 tons per square inch and a third reading taken.

The third reading shall not exceed the first reading by more than ·0004 inch.

Number of Test Pieces

708 One tensile test piece is to be made from at least every fifth plate or bar, as rolled, from each charge. This test piece is to be used for determining both the limit of proportionality and the tensile strength. The Surveyor should select a sample from each variation of thickness of ·10 of an inch in the plates or bars from each charge.

Cold Bend Tests

709 A cold bend test is to be taken both lengthwise and crosswise from every plate (bars lengthwise only). The test pieces are to withstand without fracture, being doubled over until the internal radius is equal to 1·5 times the thickness of the test pieces and the sides are parallel.

Preparation of Test Pieces

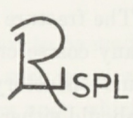
710 The test pieces are to be carefully prepared in the usual manner.

Additional Tests before Rejection

711 Where any of the test pieces first selected by the Surveyor do not fulfil the above requirements, two further tests of the same kind may be made from the same plate or bar, but where either of these fail the plate or bar from which the test pieces were cut is to be rejected.

In addition to the tests described above, the material may be subjected to further tests at the discretion of the Surveyor.

Branding

712 Every plate and bar is to be clearly and distinctly marked by the maker in two places with the Society's brand thus :—  indicating that the material has complied with the Society's tests.

Submission of Plans

713 When it is desired to use this material in the construction of ships intended to be classed in the Society's Register Book, plans showing the reduction of scantlings proposed should be submitted for the consideration of the Committee.

Alternative Proposals

714 The Committee will consider proposals for the use of special quality steel having limits different from those prescribed in this section, provided full particulars as to the properties and manufacture of the material are submitted for consideration.

Section 8

SPECIAL IRON FOR SCREW STAYS FOR COMBUSTION CHAMBERS

General

801 In order that iron screw stays may be approved of the same size as would be required for mild steel, the iron must withstand the tests described in this Section.

Number of Tensile Tests

802 The bars as rolled are to be placed in batches of 20, and one tensile test piece is to be taken from each batch. If this is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

Tensile Test

803 The tensile breaking strength is not to be less than 21½ tons per square inch, with an elongation of not less than 25 per cent measured on the standard test piece B, or of 30 per cent measured on the standard test piece C.

Bend Tests

804 Test pieces, either of the bar as rolled or turned down to 1 inch diameter, are to stand bending cold until the sides are parallel and the space between the two sides is not greater than the diameter of the test piece.

805 One ordinary bend test piece is to be taken from each batch, and a similar test piece from each batch is to be lightly and evenly nicked on one side with a sharp cutting tool and bent back at this point through an angle of 180 degrees by pressure or by a succession of light blows. The fracture must be clean, fibrous, free from slag or dirt or any coarse crystalline structure. If either of these tests is unsatisfactory, two other bars are to be selected for test, but should either of these fail the batch is to be rejected.

Section 9

STEEL CASTINGS

Process of Manufacture

901 Steel for castings is to be made by the open hearth process, acid or basic, or by such other process as may be approved by the Committee.

Heat Treatment

902 All steel castings are to be thoroughly heat treated in a properly constructed furnace, which must permit of the whole casting being uniformly raised in temperature throughout its whole extent to the necessary intensity. The casting is to be allowed to cool prior to removal from the furnace, and if afterwards heated for any purpose it is again to be similarly heat treated if required by the Surveyor.

Testing and Inspection

903 The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch, but in the event of any casting proving unsatisfactory in the course of preparation or erection, such casting is to be rejected notwithstanding any previous certificate of satisfactory testing.

904 The tensile strength and ductility are to be determined from standard test pieces, which are to be prepared from pieces cast on the casting. These pieces are not to be cut or partially cut from the castings until the heat treatment of such castings has been completed, nor until they have been stamped by the Surveyor. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

905 Where the castings are to be used for purposes for which cast iron is ordinarily employed they need not be submitted to tensile and bend tests, but they are to be submitted to the hammering tests specified in 914.

Number of Tests

906 At least one tensile test and one cold bend test are to be taken from each casting. In castings of complex design, referred to in 913, at least two tensile tests and two cold bend tests are to be taken. Where a casting is made from more than one charge of steel, at least four tensile tests and four cold bend tests are to be made upon pieces cast as far apart as possible, some test pieces being taken from as near the top, and others from as near the bottom of the casting as practicable. Where a number of charges are all mixed in one ladle before casting they may be considered as a single charge.

Dimensions of Tensile Test Pieces

907 The tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of 3½ inches.

Tensile Tests

908 The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 26 and 35 tons per square inch with an elongation of not less than 20 per cent measured on the standard test piece.

In the case of machinery parts such as boiler mountings, valve chests, turbine casings, and other important machinery castings, the tensile breaking strength is to be between the

limits of 28 and 35 tons per square inch, with a minimum elongation of 20 per cent measured on a standard test piece.

For cast steel crank webs, the tensile breaking strength of the material is to be between the limits of 28 and 35 tons per square inch and the sum of the tensile breaking strength and the percentage elongation is to be not less than 53, but in no case is the percentage elongation to be less than 20 per cent.

Dimensions of Bend Test Pieces

909 The bend test pieces are to be machined to a rectangular section 1 inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$ inch.

Bend Tests

910 The bend test pieces are to withstand, without fracture, being bent cold through an angle of 120 degrees, the internal radius of the bend being not greater than 1 inch.

They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

Additional Tests before Rejection

911 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

Percussive Tests

912 Stern frames cast in one piece are to be let fall on hard ground (excavations being made to take bosses and other projections) after being raised through an angle of 45 degrees. Stern frames cast in more than one piece, rudders, steering quadrants, crossheads and tillers, are to be dropped on hard ground from a height of from 7 to 10 feet according to the design, shape, and weight of the casting.

Castings of Complex Design

913 Castings of complex design which would be liable to be deformed if submitted to the drop or percussive test, may be exempt from this test provided two tensile tests and two cold bend tests are made upon pieces taken from positions as far apart as possible on each casting; one tensile test and one bend test should be taken from as near the top and the others from as near the bottom of the casting as practicable.

Hammering Tests

914 All castings are to be slung up and well hammered to satisfy the Surveyors that the casting is sound and without flaw. For large castings the hammer used for this test is to be not less than 7 lb. weight. In the case of castings which are subjected to the percussive tests mentioned in 912, the hammering tests are to be applied after the percussive tests.

Drilling Tests

915 In the case of large steel castings the Surveyor is to supplement the foregoing tests by drilling small holes at such parts of the castings where experience shows that cavities and contraction cracks are most likely to occur, and at positions which are to be agreed upon between the Surveyor and the manufacturer, in order to determine the soundness or otherwise of the casting. These holes are afterwards to be tapped and properly filled up with screw plugs.

Branding

916 Every casting, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the casting has complied with the Society's requirements.

Section 10

INGOT STEEL FORGINGS

Process of Manufacture

1001 Ingot steel for forgings is to be made by the open hearth process, acid or basic, or by such other process as may be approved by the Committee.

1002 The forgings are to be sound and are to be made from sound ingots; all important forgings such as stern frames rudder heads and main pieces of rudders upon which arms are shrunk, crank and other shafts, connecting rods and piston rods, are to be gradually and uniformly forged. The sectional area of the body of the forging (as forged) is not to exceed one-fifth of the sectional area of the original ingot, and no part of the forging (as forged) is to have more than two-thirds of the sectional area of the original ingot.

1003 Where ingots are cast in chilled moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads, the sectional area of any part of the forging (as forged) is not to exceed:—

One-third of the sectional area of the ingot where the length at any diameter is greater than its diameter.

Two-thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Heat Treatment

1004 All important ingot steel forgings are to be suitably heat treated in a properly constructed furnace, which must permit of the whole forging being uniformly heated throughout to the necessary temperature. If the forging be subsequently heated for any further forging, it is again to be similarly heat treated.

Testing and Inspection

1005 The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch ; but, in the event of any forging proving unsatisfactory in the course of preparation or erection, such forging is to be rejected notwithstanding any previous certificate of satisfactory testing.

1006 The tensile strength and ductility are to be determined from standard test pieces which are to be prepared from sample pieces cut lengthwise from the forging from a part of not less sectional dimensions than the body of the forging. In the case of crank webs the test pieces are to be taken crosswise from the webs as rolled or forged. Such standard test pieces are to be machined from the sample pieces without forging down, and the sample pieces are not to be detached from the forging until the heat treatment of such forging has been completed. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

Number of Tests

1007 At least one tensile and one cold bend test piece are to be taken from each forging or multiple forging. In the case of forgings or multiple forgings exceeding both 3 tons in weight and 8 feet in length, one tensile test and one cold bend test piece are to be taken from each end of each forging or multiple forging.

Dimensions of Tensile Test Pieces

1008 The tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of $3\frac{1}{2}$ inches.

In cases where the dimensions of the forging will not permit the use of one of these test pieces, any other standard round test piece can be used, provided it is of the largest practicable size and has a gauge length equal to four times the square root of the cross sectional area.

Tensile Tests

1009 The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 28 and 40 tons per square inch, with a range not exceeding 4 tons per square inch in any one forging, and in no case is the sum of the tensile breaking strength and percentage of elongation, measured on the standard test piece, to be less than 57 for test pieces cut longitudinally. Where the tensile test pieces are required to be taken transversely this sum is to be not less than 52.

1010 Stern posts, propeller posts, rudders, and other ship forgings which are to be forge welded may be made of specially soft open hearth ingot steel instead of wrought iron, such steel to have a tensile breaking strength between the limits of 22 and 26 tons per square inch, with an elongation on the standard test piece (*see* 1008) of not less than 35 per cent for 22 ton steel and 31 per cent for 26 ton steel ; in no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57. The remaining tests and requirements are to be as prescribed for ordinary ingot steel.

Dimensions of Bend Test Pieces

1011 The bend test pieces are to be machined to a rectangular section 1 inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$ inch.

Bend Tests

1012 The bend test pieces are to withstand, without fracture, being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below, for test pieces taken longitudinally :—

Up to 32 tons per square inch	$\frac{1}{4}$ inch.
Above 32 tons and up to 36 tons per square inch ...	$\frac{3}{8}$ inch.
Above 36 tons and up to 40 tons per square inch...	$\frac{5}{8}$ inch.

Where the test pieces are required to be taken transversely, the internal radius of the bend should be not greater than $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and $1\frac{1}{4}$ inches respectively, for the tensile strengths as stated above.

They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

Additional Tests before Rejection

1013 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the forging, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the forging is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

General

1014 The requirements as to heat treatment and testing are intended to apply to rudder heads and main pieces of rudders upon which arms are shrunk, to shafts of all descriptions, also to connecting rods and piston rods which require to be made in several heats. They are not intended to apply to small forgings which during their last stage of manufacture are uniformly heated throughout.

Special Quality Steel for Forgings

1015 Where steel material is proposed having tensile strength other than that specified in this Section, the particulars of the mechanical properties of the material should be submitted for consideration.

Forged Rotors

1016 In the case of forged rotors which rotate at a peripheral speed greater than 600 feet per second, longitudinal, tangential and radial sets of test pieces, each set comprising tensile and bend tests, should be taken and the proposed mechanical properties should be submitted for consideration.

Branding

1017 Every forging, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the forging has complied with the Society's requirements.

Section 11

SEAMLESS STEEL DRUMS FOR BOILERS

Process

1101 The steel is to be made by the open hearth process, acid or basic.

Discard

1102 Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled.

Forging

1103 The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively hollow cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of the hollow ingot, as cast, shall be reduced in thickness by at least two-thirds in the process of forging.

The Committee will be prepared to give consideration to the circumstances of any special case.

Heat Treatment and Testing

1104 Sufficient material shall be left on each end of each forging to enable tangential tests to be taken. These tests are to consist of one tensile test and one bend test from each end. In the case of open-ended drums the test material shall not be parted off before heat treatment, but, if the drums are closed in, the test rings may be parted prior to this operation ; subsequently the test rings and the forging shall be simultaneously heat treated in the same furnace.

If desired, test pieces may be heated for the purpose of straightening, but this operation must not cause any alteration in the sectional area of the test pieces, which are subsequently to be heat treated simultaneously with the drum.

Tensile Tests

1105 The tensile breaking strength is to be between the limits of 28 and 40 tons per square inch, but the difference in the tensile strengths at each end of a forging is not to exceed 4 tons per square inch.

The percentage of elongation measured on a standard test piece (*see* P 1008) is to be between 29 and 17, and in no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57.

Bend Tests

1106 Test pieces 1 inch by $\frac{3}{4}$ inch are to be capable of being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below :—

Up to 32 tons per square inch	$\frac{1}{4}$ inch.
Above 32 tons and up to 36 tons per square inch...	$\frac{3}{8}$ inch.
Above 36 tons and up to 40 tons per square inch...	$\frac{5}{8}$ inch.

Retesting

1107 Should either the tensile test or the bend test fail, two further specimens may be tested and if the results obtained from both are satisfactory the forging shall be accepted. In the event of either or both retests failing, the forging may be again heat treated and re-presented for test.

Section 12

REDUCTION GEAR PINIONS AND GEAR WHEEL RIMS

Materials

1201 The materials used for pinions, pinion sleeves and gear wheel rims are to comply with the following requirements.

The steel is to be made by the acid open hearth or electric processes.

Ingots are to be cast in chilled moulds with the larger diameter or cross sections uppermost and with efficient refractory feeder heads.

Pinions

1202 Pinions are to be made from nickel steel.

The chemical composition is to be as follows:—

Carbon ...	0·24	to	0·35	per cent
Nickel ...	3·25	to	3·75	per cent
Sulphur ...	not to exceed		·035	per cent
Phosphorus	not to exceed		·035	per cent

In cases where it is desired to use alternative alloys full details of the chemical composition, physical properties and heat treatment are to be submitted for the consideration of the Committee.

Manufacture of Forgings

1203 The forgings are to be gradually and uniformly forged from ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentages of the total weight from the top of the ingot:—

Weight of Ingot	Minimum top discard
Below 2 tons	15 per cent
2 to 5 tons	18 per cent
Over 5 tons	25 per cent

1204 The sectional area of any part of the forging (as forged) is not to exceed:—

One third of the sectional area of the ingot where the length at any diameter is greater than its diameter.

Two thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Sleeves are to be hollow forged or hollow rolled where practicable.

1205 The forgings are to be made with sufficient material on the portion on which the teeth will be cut to allow not less than the following amounts being machined from surfaces of the finished forging before heat treatment, but leaving $\frac{1}{4}$ inch on all surfaces :—

Large forgings for pinions 6 inches and over in diameter over the toothed portion when finished—1 inch on diameters.

Small forgings for pinions under 6 inches in diameter over the toothed portion when finished—$\frac{3}{4}$ inch on diameters.

Heat Treatment

1206 The forgings may be normalised and tempered or, alternatively, may be oil hardened and tempered.

Test Pieces

1207 Longitudinal Tests.—One set of longitudinal test pieces, comprising tensile, bend and impact tests, is to be taken from one end of each pinion forging (or multiple forging), but if the length of the forging (or multiple forging) exceeds 48 inches, a set is to be taken from each end.

1208 Transverse Tests.—Where the diameter of the body portion of the pinion or sleeve forging exceeds 8 inches, one set of transverse test pieces, comprising tensile, bend and impact tests, is to be taken from one end of the body portion or sleeve, but if the length of the body portion or sleeve exceeds 30 inches, a set is to be taken from each end.

In the case of single forgings having two body pieces and multiple forgings, where the sum of the lengths of the sleeves or body portions, including centre journals, exceeds 30 inches and the diameter exceeds 8 inches, one set of transverse test pieces is to be taken from each of the two outer ends of the multiple of sleeves or the end body portions of the forging.

These transverse tests are additional to the longitudinal tests required to be taken from pinion forgings.

Where transverse tests are required from a pinion forging, but the difference in the diameters of the body portion and journal is such that it is not practicable to obtain transverse test pieces adjacent to the body portion, these should be taken from the ends of the forging.

Batch Testing

1209 Where a number of pinion forgings of the same dimensions are forged separately from the same cast and heat treated together in batches, and each forging does not exceed either a length of 48 inches or a weight of 3 cwts. as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of longitudinal and transverse tests from each of these forgings in accordance with the foregoing and including sulphur prints may be taken as representative of the batch. The results of these tests are to be confirmed by Brinell tests carried out on all forgings in accordance with 1214.

Mechanical Properties

1210 The forgings after heat treatment are to have the mechanical properties as detailed in 1211 to 1215.

Tensile Tests

1211 The ultimate tensile strength, measured on a standard test piece 2 inches by ·564 inch diameter, is to be not less than 40 tons per square inch, longitudinal and transverse.

The yield point is to be not less than 60 per cent of the ultimate tensile strength, longitudinal and transverse.

The elongation is to be not less than 23 per cent in 2 inches longitudinal and 16 per cent in 2 inches transverse.

Bend Tests

1212 The longitudinal and transverse bend test pieces are to withstand, without fracture, being bent through an angle of 180 degrees, the internal radius of the bend being not greater than $\frac{3}{4}$ inch.

The dimensions of the test piece are to be $\frac{3}{4}$ inch by $\frac{3}{8}$ inch.

Impact Tests

1213 Test specimens cut longitudinally 10 mm. square with a V notch 2 mm. deep having an included angle of 45 degrees with ·25 mm. radius at root, are to give a value of not less than 35 ft. lb. in the case of oil hardened and tempered steels and not less than 20 ft. lb. in the case of normalised and tempered steels.

Where the test pieces are cut transversely the foregoing values are to be 20 ft. lb. and 15 ft. lb. respectively.

Brinell Tests

1214 Brinell tests are to be taken on all forgings, after machining to $\frac{1}{4}$ inch over the finished diameter after heat treatment. The impressions are to be taken at each end of two diameters at right angles in three different positions over each toothed portion of the pinion. The forging will be considered sufficiently uniform if there is not more divergence than 30 in Brinell number between any two readings.

Sulphur Prints

1215 Sulphur prints are to be taken over the whole of the body portions of the forging on which teeth are to be cut, and in addition from each end of the body portions.

Gear Wheel Rims

Manufacture of Forgings

1216 The rims are to be gradually and uniformly forged or rolled from ingots from which top and bottom discards, not less than required in the case of pinions, have been taken.

The forging for a single gear wheel rim is to be made sufficiently long to allow one set of transverse test pieces, comprising tensile and bend tests, to be taken from one end of the forging. In the case of multiple forgings, one set of transverse tests taken from each end of the forging will be sufficient, provided all the portions cut from the multiple forging are heat treated together.

Batch Testing

1217 Where a number of gear wheel rims of the same dimensions are forged from the same cast and heat treated together in batches, and do not exceed 3 cwts. each as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of transverse tests from each of these forgings in accordance with the foregoing may be taken as representative of the batch.

Heat Treatment

1218 All rim forgings after completion are to be efficiently normalised.

Mechanical Properties

1219 The forgings after heat treatment are to have the mechanical properties as detailed in 1220 to 1226.

Tensile Tests

1220 The ultimate tensile strength, measured on a standard test piece 2 inches by ·564 inch diameter cut circumferentially, is to be between the limits of 31 and 35 tons per square inch. The sum of the tensile breaking strength in tons per square inch and percentage of elongation, measured on a standard test piece, is to be not less than 57.

Dimensions of Bend Test Pieces

1221 The bend test pieces are to be machined to a rectangular section 1 inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$ of an inch.

Bend Tests

1222 The bend test pieces are to withstand, without fracture, being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than $\frac{3}{8}$ inch. They are to be bent over the thinner section.

General

1223 Gear wheel rims may be made of steel having a greater ultimate tensile strength than 35 tons per square inch, but in such cases full details of the mechanical properties should be submitted for approval.

1224 In cases where separate rims are not used and the wheels are of solid forged construction, the mechanical properties of the material are to comply with 1219 to 1222. Where, however, such wheels are of cast steel construction, full details of the chemical analysis, heat treatment and mechanical properties should be submitted for approval.

1225 All forgings for pinions and wheel rims are to be sound and free from defects. Forgings may be rejected after the cutting of teeth, if defects are then revealed, notwithstanding acceptance during the earlier stages of manufacture.

1226 Steels for parts used in the construction of gearing other than pinions and wheel rims shall comply with the requirements of P 5 or P 10, as the case may be.

Section 13

BOILER TUBES AND PRESSURE PIPES

General

1301 The steel is to be made by the open hearth or other approved process.

All tubes and pipes are to be free from defects both within and without.

The following requirements and tolerances are based on British practice and manufacturing standards; they are applicable to carbon steel materials only.

Alternative requirements and tolerances in accordance with other approved national standards may be accepted.

Alloy steel tubes and pipes for which no provision is made in this Section will be required to comply with comparable approved tests appropriate to the material or with the terms of an approved specification.

Tubes for Water Tube Boilers and Superheaters

1302 All tubes subject to internal pressure are to be solid drawn, unless otherwise specially approved.

1303 All tubes under $1\frac{1}{2}$ inches external diameter are to be cold finished; these, and all other cold-drawn tubes, are to be satisfactorily annealed before examination.

1304 The tensile strength of the material is not to exceed 28 tons per square inch, and the elongation is not to be less than 30 per cent on a standard test piece C, when in the billet or bar form, and is to be certified as such by the makers of the steel and of the tubes.

1305 All tubes up to 10 L.S.G. in thickness are to be capable of being flattened by hammering when cold until the inner surfaces are not further apart than $\frac{2}{32}$ inch. For those over 10 L.S.G., and not exceeding 6 L.S.G., the maximum distance apart is to be $\frac{7}{32}$ inch; for those over 6 L.S.G., and not exceeding 3 L.S.G., the maximum distance apart is to be $\frac{12}{32}$ inch; and for those whose thickness exceeds 3 L.S.G., the maximum is to be $\frac{18}{32}$ inch. In all cases after undergoing such tests there are not to be any signs of cracking or other fracture.

1306 All tubes when cold are to be able to withstand, without cracking, an enlargement of diameter at both ends by means of roller expanders, or by drifts to the extent of:—

Thickness of tubes	Enlargement of diameters at ends by means of	
	Roller Expanders	Drifts
Up to 10 L.S.G.	12·5 per cent	9·5 per cent
Over 10 L.S.G. & up to 6 L.S.G.	9·5 per cent	7·0 per cent
Over 6 L.S.G.	6·5 per cent	5·5 per cent

1307 Tubes should be presented for test in batches of 100 each. Two tubes are to be selected indiscriminately from each of at least two batches, and one from each of any remaining batches. Each tube so selected is to be subjected to the expanding tests, prescribed in 1306, and one tube from each batch, which may be a tube that has sustained the expansion test, is also to be flattened cold to the extent specified in 1305 at three different parts of its length, of which one position is to be at or near the middle of the tube, and the flattened portions are to be in three different planes. The tubes are to pass these tests without signs of cracking.

1308 Should one of the selected tubes fail to withstand either of these tests, two further tubes are to be selected from the batch and be subjected to both the prescribed tests. If further failure occurs the particular batch of tubes is to be rejected as unsatisfactory.

1309 Every tube is to be tested at the tube maker's works by hydraulic pressure in accordance with the following table governing the relation between the test pressure and the design pressure.

Design pressure = DP. lb. per square inch	Minimum test pressure. lb. per square inch
Up to and including 500	1,000
Over 500 up to and including 1,000	2 × DP
Over 1,000	DP + 1,000

1310 The manufacturer's certificate of the results of the foregoing tests may, at the discretion of the Surveyor, be accepted provided each tube is delivered with 1 inch in excess of the finished length, which excess is to be partly severed for flattening to the extent prescribed in 1305.

1311 Every tube delivered is to be straight (unless otherwise specified) and is to be practically concentric throughout its length. The tolerance or deviation from the specified thickness, measured at any point, is to be within the following limits :—

External diameters of tubes	Permissible variation	
	Hot Finished	Cold Finished
	Per cent	Per cent
Up to and including $2\frac{1}{2}$ ins.	$\left\{\begin{array}{l} -\ 7{\cdot}5 \\ +\ 17{\cdot}5 \end{array}\right.$	$\left\{\begin{array}{l} -\ 5{\cdot}0 \\ +\ 10{\cdot}0 \end{array}\right.$
Over $2\frac{1}{2}$ ins. up to $4\frac{1}{2}$ ins...	$\left\{\begin{array}{l} -\ 5{\cdot}0 \\ +\ 15{\cdot}0 \end{array}\right.$	$\left\{\begin{array}{l} -\ 5{\cdot}0 \\ +\ 10{\cdot}0 \end{array}\right.$
Over $4\frac{1}{2}$ ins.	$\left\{\begin{array}{l} -\ 7{\cdot}5 \\ +\ 17{\cdot}5 \end{array}\right.$	$\left\{\begin{array}{l} -\ 5{\cdot}0 \\ +\ 10{\cdot}0 \end{array}\right.$

The external diameter of the tubes, measured at any point, is to be within the following tolerances of the specified diameter :—

External diameters of tubes	Permissible variation	
	Hot Finished	Cold Finished
Up to and including $2\frac{1}{2}$ ins.	$\left\{\begin{array}{l} +\ \frac{1}{64}\text{ inch} \\ -\ \frac{1}{32}\text{ inch} \end{array}\right.$	+ 0 per cent − 1 per cent
Over $2\frac{1}{2}$ ins.	$\left\{\begin{array}{l} +\ 1\text{ per cent} \\ -\ 1\text{ per cent} \end{array}\right.$	+ 0 per cent − 1 per cent

Boiler Smoke Tubes

Lap Welded or Seamless

1312 The tensile strength of the material is not to exceed 28 tons per square inch, with a minimum elongation of 20 per cent on a standard test piece having a gauge length of 8 inches.

1313 The tolerance or deviation from the specified thickness, measured at any point, is to be within the following limits :—

− 10 per cent
+ 10 per cent

1314 The external diameter of the tubes, measured at any point, is to be within the following tolerances of the specified diameter :—

External diameter of tubes	Permissible variation
Below $2\frac{1}{2}$ ins.	$\left\{\begin{array}{l} +\ \frac{1}{64}\text{ inch} \\ -\ \frac{1}{32}\text{ inch} \end{array}\right.$
$2\frac{1}{2}$ ins. and over...	$\left\{\begin{array}{l} +\ 1\text{ per cent} \\ -\ 1\text{ per cent} \end{array}\right.$

Pressure Pipes

Seamless Pipes

1315 The tensile strength of the steel is to be between 23 and 30 tons per square inch, with a minimum elongation of 20 per cent on a standard test piece having a gauge length of 8 inches.

Lap Welded Pipes

1316 The tensile strength of the steel is to be between 22 and 28 tons per square inch, with a minimum elongation of 25 per cent on a standard test piece having a gauge length of 8 inches.

Section 14

BRONZE PROPELLERS AND BRONZE PROPELLER BLADES

Number of Tests

1401 At least one tensile test is to be taken from each casting.

Dimensions of Test Piece

1402 The tensile test pieces are to be turned so as to have a diameter of ·564 inch or ·798 inch, with a gauge length of 2 inches.

Tensile Tests

1403 The tensile breaking strength determined from test pieces of standard dimensions is to be not less than 28 tons per square inch, and the sum of the tensile breaking strength and percentage of elongation measured on the standard test piece, is to be not less than 48. In no case, however, is the percentage of elongation to be less than 15.

Section 15

ANCHORS

Process of Manufacture

1501 Anchors are to be made of forged wrought iron, or forged open hearth ingot steel, or cast steel; the use of Bessemer steel is prohibited.

1502 Each important part of a forged anchor is to be plainly marked by the makers with the words "forged wrought iron," or "forged open hearth ingot steel," as the case may be.

1503 Steel anchor shackles are to be forged and unwelded, or may be of cast steel provided the material of which they are manufactured complies with the requirements of P 9.

PROOF TESTS FOR ANCHORS

Weight	Test	Weight	Test	Weight	Test	Weight	Test	Weight	Test	Weight	Test
Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons
1	3·40	24	23·90	47	40·50	70	53·75	93	64·50	116	73·25
2	4·50	25	24·75	48	41·15	71	54·25	94	65·00	117	73·65
3	5·50	26	25·65	49	41·75	72	54·75	95	65·40	118	74·00
4	6·40	27	26·40	50	42·40	73	55·25	96	65·75	119	74·40
5	7·40	28	27·15	51	43·00	74	55·75	97	66·15	120	74·75
6	8·25	29	27·90	52	43·65	75	56·25	98	66·50	121	75·10
7	9·25	30	28·65	53	44·25	76	56·75	99	66·90	122	75·40
8	10·15	31	29·40	54	44·75	77	57·25	100	67·25	123	75·70
9	11·15	32	30·15	55	45·40	78	57·65	101	67·65	124	76·00
10	12·00	33	30·90	56	46·00	79	58·15	102	68·00	125	76·35
11	12·90	34	31·65	57	46·65	80	58·50	103	68·40	126	76·65
12	13·90	35	32·40	58	47·25	81	59·00	104	68·75	127	76·95
13	14·75	36	33·15	59	47·75	82	59·50	105	69·15	128	77·25
14	15·65	37	33·75	60	48·40	83	60·00	106	69·50	129	77·60
15	16·50	38	34·50	61	48·90	84	60·50	107	69·90	130	77·90
16	17·40	39	35·15	62	49·50	85	61·00	108	70·25	140	81·00
17	18·25	40	35·75	63	50·00	86	61·50	109	70·65	150	84·15
18	19·00	41	36·50	64	50·50	87	61·90	110	71·00	160	86·75
19	19·90	42	37·15	65	51·00	88	62·25	111	71·40	170	89·25
20	20·75	43	37·90	66	51·50	89	62·75	112	71·75	180	91·75
21	21·65	44	38·65	67	52·15	90	63·25	113	72·15	190	94·25
22	22·40	45	39·25	68	52·65	91	63·65	114	72·50	200	96·75
23	23·15	46	39·90	69	53·25	92	64·00	115	72·90	—	—

The weight given in the above Table is either for stockless anchors or for stocked anchors without the stock.
For intermediate weights the test may be obtained by interpolation.

Tests of Anchors

1504 All anchors, including stream and kedge anchors weighing more than 168 lbs. inclusive of stock, are to be tested in accordance with the requirements of the preceding table and the certificates of test produced.

Section 16

CAST STEEL ANCHORS

General

1601 All cast steel anchors in addition to undergoing the statutory tests are to be subjected to the percussive, hammering and bending tests detailed in this Section.

These tests are to be carefully and completely made in the presence and to the satisfaction of the Surveyors.

Percussive Test

1602 The anchor, or where anchors are made in more than one piece, each piece is to be raised a given height and then dropped on a steel or iron slab.

For weights of 15 cwts. and below, the height is to be 15 feet, and for weights above 15 cwts. the height is to be 12 feet.

The lowest part of the anchor or piece when suspended is to be at least the given height above the slab upon which it is to be dropped.

1603 An anchor of the Admiralty pattern is first to be raised vertically to the given height with its shank and arms in a horizontal position, and then let fall from that height.

It is then to be raised a second time to the given height and suspended with the crown downwards. Two steel or iron blocks are to be placed underneath it, and the anchor is to be let fall from this position so that one of the blocks receives it on the middle of one arm, and the other block receives it on the middle of the other arm.

1604 The slab for the horizontal test is to be of steel or iron, well laid on a solid concrete foundation to the satisfaction of the Surveyor.

1605 If the slab on which the anchor falls is broken by the impact the test is to be repeated until a slab is made that does not break.

1606 The blocks for the vertical test are to be solid and of sufficient height to prevent the crown of the anchor from touching the slab, and are to be to the satisfaction of the Surveyor.

Hammering Test

1607 Provided the percussive test has been satisfactory, the anchor or piece is to be slung and thoroughly hammered over its parts with a sledge hammer weighing not less than 7 lb., and is required to give under this treatment such a clear ring in all its parts as shall satisfy the Surveyor that the casting is sound and that no flaws have developed by the application of the preceding percussive tests.

Bending Test

1608 Cast steel may be passed as sufficiently ductile for anchors when a piece of each casting 8 inches in length, is cut from the casting, turned to 1 inch in diameter, and is then bent cold by hammering through an angle of 90 degrees over a radius of $1\frac{1}{2}$ inches, without showing signs of flaw or fracture.

1609 A piece is to be cast on each cast steel anchor or on each portion of such anchor when it is made of more than one casting, and each piece is to be of sufficient size to enable one test piece of the size stated in 1608 to be cut out of it, or at the discretion of the manufacturer, it may be of sufficient size to enable four test pieces to be cut out of it.

1610 Where it is only of sufficient size to enable one test piece to be cut out of it, that piece is to be subjected to the bending test required by 1608, and should it fail to withstand the test the casting is to be rejected.

1611 Where the piece is large enough to enable four test pieces to be cut out of it, one of these is to be turned to 1 inch in diameter for a length of 8 inches, and bent cold through an angle of 90 degrees over a radius of $1\frac{1}{2}$ inches, and should the piece withstand this test without flaw or fracture it shall be deemed to have withstood a satisfactory test for ductility.

1612 Should the one test piece not pass this test, all or any of the other three test pieces may be tested in a similar manner, and should any one of the four test pieces pass this test, the anchor, or part of the anchor, as the case may be, shall be deemed so far satisfactory.

Heat Treatment

1613 Each anchor is to be thoroughly heat treated and marked "annealed steel."

Section 17

CHAIN CABLES, STREAM CHAINS AND STEERING CHAINS

1701 All chain cables, stream and steering chains are to be tested in accordance with the requirements of the following tables and the certificates of test produced.

Stud Link Chain Cables

Minimum Size	CABLES OF WROUGHT IRON		CABLES OF SPECIAL STEEL		Minimum Weight per Length of 15 fms.	Minimum Size	CABLES OF WROUGHT IRON		CABLES OF SPECIAL STEEL		Minimum Weight per Length of 15 fms.
	Proof Test	Breaking Test	Proof Test	Breaking Test			Proof Test	Breaking Test	Proof Test	Breaking Test	
Ins.	Tons	Tons	Tons	Tons	Cwts.	Ins.	Tons	Tons	Tons	Tons	Cwts.
7/16	3·40	5·10	4·80	7·10	1¾	2 3/16	86·15	120·50	120·50	168·70	35⅞
½	4·50	6·75	6·30	9·50	2⅛	2¼	91·15	127·50	127·50	178·50	37⅞
9/16	5·65	8·40	7·90	11·80	2⅝	2 5/16	96·25	134·75	134·75	188·75	40
⅝	7·00	10·50	9·80	14·70	3¼	2⅜	101·50	142·10	142·10	198·90	42¼
11/16	8·50	12·75	11·90	17·90	3⅝	2 7/16	106·90	149·65	149·65	209·50	44½
¾	10·15	15·15	14·20	21·20	4⅜	2½	112·50	157·50	157·50	220·50	47
13/16	11·90	17·80	16·60	24·90	5⅛	2 9/16	116·70	163·40	163·40	228·70	49½
⅞	13·75	20·65	19·30	28·90	5⅞	2⅝	120·90	169·25	169·25	237·00	52
15/16	15·80	23·70	22·10	33·20	6¾	2 11/16	125·10	175·15	175·15	245·20	54½
1	18·00	27·00	25·20	37·80	7⅝	2¾	129·30	181·00	181·00	253·40	57⅛
1 1/16	20·30	30·40	28·40	42·60	8⅝	2 13/16	133·40	186·75	186·75	261·50	59⅞
1⅛	22·75	34·15	31·90	47·80	9¾	2⅞	137·60	192·65	192·65	269·70	62⅝
1 3/16	25·40	38·00	35·50	53·20	10⅞	2 15/16	141·70	198·40	198·40	277·70	65½
1¼	28·15	42·15	39·40	59·00	12	3	145·80	204·10	204·10	285·70	68⅜
1 5/16	31·00	46·50	43·40	65·10	13¼	3 1/16	149·80	209·70	209·70	293·60	71¼
1⅜	34·00	51·00	47·60	71·40	14½	3⅛	153·75	215·25	215·25	301·40	74¼
1 7/16	37·15	55·65	52·00	77·90	15⅞	3 3/16	157·70	220·75	220·75	309·10	77⅜
1½	40·50	58·70	56·70	82·20	17¼	3¼	161·60	226·20	226·20	316·70	80⅜
1 9/16	43·90	61·40	61·40	86·00	18¾	3 5/16	165·40	231·50	231·50	324·10	83⅝
1⅝	47·50	66·50	66·50	93·10	20	3⅜	169·15	236·75	236·75	331·50	86⅞
1 11/16	51·25	71·75	71·75	100·50	21½	3 7/16	172·75	241·80	241·80	338·50	90⅛
1¾	55·15	77·15	77·15	108·00	23⅛	3½	176·40	246·90	246·90	345·70	93½
1 13/16	59·15	82·75	82·75	115·90	24⅞	3 9/16	179·90	251·80	251·80	352·50	96¾
1⅞	63·25	88·50	88·50	123·90	26⅝	3⅝	183·25	256·50	256·50	359·00	100
1 15/16	67·50	94·50	94·50	132·30	28⅜	3 11/16	186·50	261·10	261·10	365·50	103⅜
2	72·00	100·80	100·80	141·10	30	3¾	189·80	265·70	265·70	372·00	106⅝
2 1/16	76·50	107·10	107·10	149·90	31⅞	3 13/16	192·90	270·00	270·00	378·00	109⅞
2⅛	81·25	113·75	113·75	159·30	33¾	3⅞	195·90	274·25	274·25	384·00	113¼

SHORT LINK CHAIN CABLES

Minimum Size	Proof Test	Breaking Test	Minimum Weight per Length of 15 fms.		Minimum Size	Proof Test	Breaking Test	Minimum Weight per Length of 15 fms.	
			Forged	Electric welded				Forged	Electric welded
Ins.	Tons	Tons	Cwts.	Cwts.	Ins.	Tons	Tons	Cwts.	Cwts.
$\frac{7}{16}$	2·25	4·50	2	1·5	$1\frac{1}{4}$	18·75	37·50	12·9	11·8
$\frac{1}{2}$	3·00	6·00	2·5	1·9	$1\frac{5}{16}$	20·65	41·25	14·1	13·0
$\frac{9}{16}$	3·75	7·50	3	2·4	$1\frac{3}{8}$	22·65	45·25	15·5	14·3
$\frac{5}{8}$	4·65	9·25	3·5	3·0	$1\frac{7}{16}$	24·75	49·50	17	15·6
$\frac{11}{16}$	5·65	11·25	4	3·6	$1\frac{1}{2}$	27·00	54·00	18·4	17·0
$\frac{3}{4}$	6·75	13·50	4·8	4·3	$1\frac{9}{16}$	29·25	58·50	19·9	18·4
$\frac{13}{16}$	7·90	15·80	5·5	5·0	$1\frac{5}{8}$	31·65	63·25	21·5	19·9
$\frac{7}{8}$	9·15	18·25	6·4	5·8	$1\frac{11}{16}$	34·15	68·25	23·1	21·5
$\frac{15}{16}$	10·50	21·00	7·3	6·7	$1\frac{3}{4}$	36·75	73·50	25	23·1
1	12·00	24·00	8·3	7·6	$1\frac{13}{16}$	39·40	78·80	26·9	24·8
$1\frac{1}{16}$	13·50	27·00	9·3	8·6	$1\frac{7}{8}$	42·15	84·25	28·9	26·5
$1\frac{1}{8}$	15·15	30·25	10·4	9·6	$1\frac{15}{16}$	45·00	90·00	30·9	28·3
$1\frac{3}{16}$	16·90	33·80	11·6	10·7	2	48·00	96·00	33	30·2

Section 18

STEEL WIRE TOWLINES, MOORING ROPES AND STANDING RIGGING; FIBRE ROPES

Note:—For list of manufacturers of steel wire towlines, mooring ropes and standing rigging see Appendix to this Chapter.

General

1801 Each manufacturer is required to provide on his premises machines suitable for making the prescribed tests satisfactorily, and the works are to be at all times open to the inspection of the Surveyors, who are empowered to retest any rope for which a certificate has been issued by the manufacturer. Periodical inspections should be held at intervals not exceeding two years.

Certificates

1802 Printed forms of certificates, approved by the Committee, are to be signed by the manufacturers, and will be supplied to them upon application to the Secretary.

Material

1803 The wire used in the manufacture of the ropes is to be drawn from steel billets made by the open hearth process and to have a tensile strength within the range shown in the table in 1805. The wire is to be of homogeneous quality, free from defects, and of smooth uniform finish.

Galvanising

1804 The wire is to be galvanised to the satisfaction of the Surveyors.

Construction of Ropes

1805 The construction of the wire rope and the ultimate tensile strength of the wire are given in the following table:—

Purpose	Construction of Rope			Construction of Strands	Ultimate tensile strength of wire
	Strands	Wire	Core		Tons per sq. in.
For Standing Rigging	6 of 7		Fibre	6 over 1	45 to 55
	6 of 19		Fibre	12 over 6 over 1	85 to 95
Mooring wires, Stream wires and Towlines	6 of 12		Fibre	12 over fibre core	85 to 95
	6 of 24		Fibre	15 over 9 over fibre core	85 to 95
	6 of 37		Fibre	18 over 12 over 6 over 1	85 to 95

Tests of Ropes

1806 A portion of each steel wire rope is to be tested to destruction and its ultimate breaking load must not be less than that given in the following table:—

Circumference	Type and Breaking Load					Circumference
	6 × 7	6 × 12	6 × 19	6 × 24	6 × 37	
Inches	Tons	Tons	Tons	Tons	Tons	Inches
1	1·8	2·0	3·1	2·6		1
1¼	2·9	3·1	4·7	4·3		1¼
1½	4·2	4·4	6·7	6·0		1½
1¾	5·8	5·9	9·1	8·5		1¾
2	7·6	8·0	12·4	10·9		2
2¼	9·5	10·5	16·3	14·2		2¼
2½	11·8	12·3	19·1	17·2		2½
2¾	14·3	14·8	22·9	20·5		2¾
3	17·1	17·6	27·0	25·0	27·3	3
3¼	20·1	21·1	32·5	28·9	29·8	3¼
3½	23·4	24·4	37·5	34·2	34·9	3½
4	30·0	32·3	49·5	43·6	46·5	4
4½	38·5	41·3	63·5	57·0	59·8	4½
5	47·5	49·5	76·0	68·9	74·7	5
5½			88·4	82·0	89·0	5½
6			104·5	96·3	107·0	6
6½				107·4	121·0	6½
7				123·5	140·0	7
7½					153·9	7½
8					173·9	8

1807 If facilities are not available for making the above tests on the rope, then a specimen is to be cut from the rope and each wire tested separately to destruction.

The breaking strength of the rope shall be considered to be the sum of the aggregate breaking loads of the individual wire less a percentage for laying up as follows:—

6 × 7	... ...	5 per cent
6 × 12	... ...	7½ per cent
6 × 19	... ...	10 per cent
6 × 24	... ...	10 per cent
6 × 37	... ...	15 per cent

1808 The wire shall stand being wrapped tightly eight times round its own diameter and subsequently unwrapped without showing any signs of fracture of the steel. Six wires or 5 per cent of the wires in the rope, whichever is the greater number, are to be subjected to this test.

1809 Fibre Ropes

Sizes and Tests of Fibre Ropes

Circumference	3-Strand (plain or Hawser laid)	4-Strand (Shroud laid)	9-Strand (Cable laid or Water laid)
Inches	Breaking Load		
	Tons	Tons	Tons
2½	2·8	2·5	
2¾	3·3	2·9	
3	4·0	3·5	
3¼	4·6	4·1	
3½	5·3	4·7	
3¾	6·0	5·3	
4	6·8	6·0	
4¼	7·6	6·7	
4½	8·5	7·5	
4¾	9·3	8·3	
5	10·3	9·2	6·5
5½	12·4	11·0	7·7
6	14·6	12·9	9·0
6½	17·0	15·1	10·3
7	19·6	17·4	11·8
8	25·2	22·3	14·9
9	31·5	28·0	18·5
10	38·6	34·2	22·4

Section 19

APPROVAL OF ELECTRODES FOR ARC WELDING IN HULL CONSTRUCTION

1901 The manufacturer's plant and method of production of the electrodes are to be such as to ensure reasonable uniformity in manufacture.

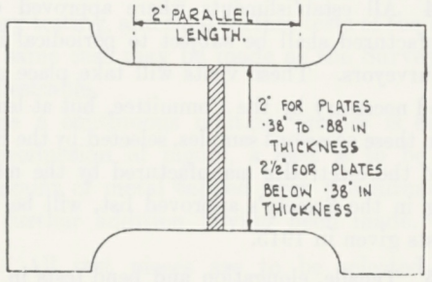
1902 Electrodes will be approved by the Committee subject to compliance with the following tests.

The test pieces are to be prepared in the presence of the Surveyor and all tests carried out under his supervision. The steel used in the preparation of the test pieces is to comply with the requirements of P 4.

1903 All test specimens are to be prepared and tested in duplicate. If one specimen fails to satisfy the test, two further specimens may be prepared, both of which must prove satisfactory.

Butt Welds

1904 TENSILE TESTS—Tensile test specimens of the form shown in the sketch are to be prepared. One of the specimens is to be of the maximum thickness which would normally be welded with square edges, and others, which are to be welded with V butts, are to be ·38, ·62 and ·88 inch in thickness. The surfaces of the welded joints are to be rendered flush on both sides.



The mean tensile strength of the test specimens for each thickness is to be not less than 26 tons per square inch.

1905 BEND TESTS—Bend tests are to be made on specimens similar to those shown above from material ·38 and ·88 inch in thickness. These are to withstand bending without fracture through an angle of 90 degrees over a bar of diameter equal to four times the thickness of the test piece. The rough edges of the samples may be removed by filing or grinding, and the test is to be made so that the wide part of the V is in tension.

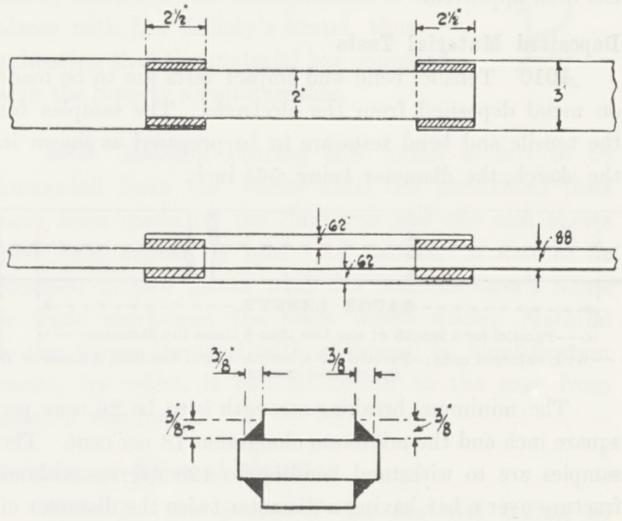
Deep Penetration Electrodes

1906 DEEP PENETRATION TESTS —Where it is desired by the manufacturer to demonstrate that an electrode has deep penetrating properties when used in the downhand welding position, the following test is to be made : two plates, of thickness equal to twice the diameter of the core of the electrode, are to be butt welded together with one downhand run of welding from each side. The plate edges are to be prepared square and ground smooth, and after tacking the gap is not to exceed 0·010 inch. The plates shall be at least 6 inches wide, and of such length as to accommodate, on each side, at least the run length of a complete electrode. The weld is to be sectioned transversely, polished and etched, and must show complete penetration throughout the joint.

The above test is to be carried out using the largest and also the smallest diameter of electrode being produced, but in the latter case not less than $\frac{1}{8}$ inch diameter. The test is to be made in duplicate for each diameter of electrode tested.

Shear Tests

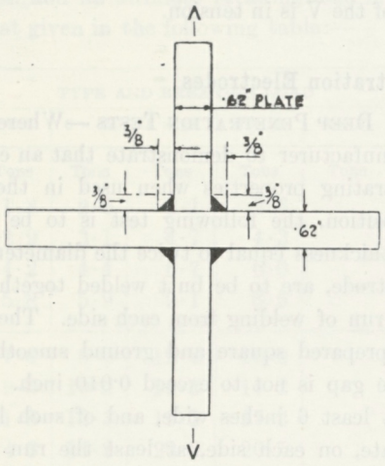
1907 Shear tests are to be carried out on specimens prepared as shown in the sketch.



The shear strength of the welds is to be not less than 17 tons per square inch, calculated on the throat thickness.

Fillet Weld Tests

1908 Fillet weld tests are to be made on samples 2 inches in width as shown in the sketch.



They are to withstand a tensile load, applied in the direction shown, of 73 × t tons, t being the throat thickness of the welds.

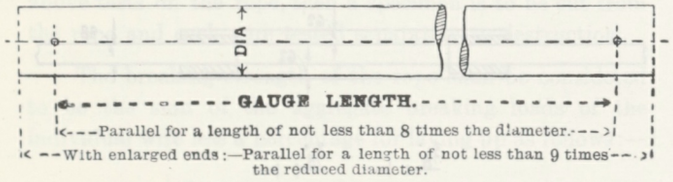
Vertical and Overhead Tests

1909 Where it is desired by the manufacturers to demonstrate that an electrode is suitable for vertical or overhead welding, tensile and bend tests are to be made from plates ·38 inch in thickness, together with fillet weld tests, as set forth in 1904, 1905 and 1908, for each position for which approval is sought.

An indication will be given in the list of approved electrodes of the positions of welding for which the electrode has been approved.

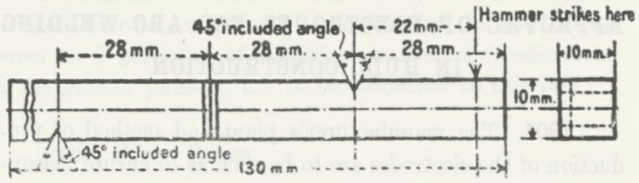
Deposited Material Tests

1910 Tensile, bend and impact tests are to be made on metal deposited from the electrode. The samples for the tensile and bend tests are to be prepared as shown in the sketch, the diameter being ·564 inch.



The minimum breaking strength is to be 26 tons per square inch and the minimum elongation 18 per cent. The samples are to withstand bending to 120 degrees without fracture over a bar having a diameter twice the diameter of the test piece.

The impact tests are to be made on a standard form of Izod test piece as shown in the sketch.



THREE NOTCH TEST PIECE.

The depth of the notch is to be 2 mm. the included angle 45 degrees, and the radius at the root ·25 mm.

The average value for each specimen is to be not less than 30 ft. lb. Other forms of impact test may be adopted with suitably modified values.

Chemical Analysis

1911 Chemical analyses of the metal of each type of electrode and of the deposited material of a weld made by the same electrode are to be supplied.

1912 The Committee is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

Maker's Certificate

1913 Each carton or package of approved electrodes is to contain a certificate from the manufacturer on the following lines :—

> "The —— Company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the Committee of Lloyd's Register of Shipping."

Periodical Inspection of Makers' Works

1914 All establishments where approved electrodes are manufactured shall be subject to periodical inspection by the Surveyors. These visits will take place as may be considered necessary by the Committee, but at least once a year. On these occasions samples, selected by the Surveyors, of each of the electrodes manufactured by the makers and appearing in the Society's approved list, will be subjected to the tests given in 1915.

1915 Tensile, elongation and bend tests in duplicate are to be made on specimens of deposited material as set forth in 1910. The specimens for tensile and elongation tests may be ·424 inch in diameter with a gauge length of $1\frac{1}{2}$ inches; if this gauge length is adopted, the minimum elongation is to be 23 per cent.

1916 The Committee may require, in any particular case, such additional tests as may be considered necessary.

9th December, 1954

TENTATIVE REQUIREMENTS FOR ALUMINIUM ALLOYS

Note:—For list of manufacturers of Aluminium Alloys for shipbuilding purposes see Appendix to this Chapter.

Section 20

ALUMINIUM ALLOY PLATES, BARS AND SECTIONS

General

2001 Aluminium alloys used in the construction of ships classed, or proposed for classification, in the Society's Register Book, are to comply with the following requirements.

These requirements, however, are not intended to apply to sheets less than ·18 inch thick, or to angles less than $1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \cdot 18''$. Where material of these scantlings is used, the physical properties and chemical composition may be in accordance with a recognised specification for an alloy suitable for marine use.

Freedom from Defects

2002 The finished material is to be free from cracks, surface flaws and lamination.

Testing and Inspection

2003 The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any material proving unsatisfactory in the course of being worked into ships due to faults in manufacture, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same cast may be made as the Surveyor may consider desirable.

Where a continuous melting process is employed for the production of ingots, a cast is to be defined as the amount of metal tapped from the furnace without any further addition having been made.

2004 All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

2005 The manufacturer is to supply to the Surveyor at the time of test a certificate of the chemical composition of the material submitted for approval and, at the discretion of the Surveyor, samples may be selected from the material for the purpose of check analyses.

Additional Tests before Rejection

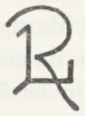
2006 Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, then:—

In the case of non-heat-treatable alloys, two further tests of the same kind may be made from the same plate, or section, but where either of these fail, the plate or section from which the test pieces were cut is to be rejected. In all such cases further tests are to be taken before any material from the same cast can be accepted.

In the case of heat-treatable alloys, the procedure laid down above is to be adopted, but the manufacturer may, should he so desire, re-heat-treat the whole of the material represented by the test piece before the two further test pieces are selected.

2007 Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the manufacturer's option, be discarded and another test made of the same plate or section.

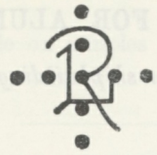
Branding

2008 Every plate or section is to be clearly and distinctly marked by the manufacturer in two places with the Society's brand, thus:—  indicating that the material has complied with the Society's requirements.

2009 Material bearing this brand is not to be forwarded from the works until the prescribed tests have been made by the Surveyor and the mill sheets have been signed by him. All material is also to be stamped in two places with the manufacturer's name or trade mark and the place where made. Material is also to be stamped with numbers, or identification marks, by which it can be traced to the cast from which it was made.

Defacing of Rejected Material

2010 In the event of the material failing to withstand the prescribed tests, the Surveyor is to see that the Society's brand, stamped on the material by

the manufacturer, has been defaced by punch marks extending beyond the brand in the form of a cross, thus:—  denoting that the material has been rejected.

Manufacturer's Certificate

2011 The mill sheets, presented to the Surveyor for signing, shall bear the following certificate printed on each sheet, with the name of the firm and initialed by the test house manager:—

"We hereby certify that the material described below satisfies the prescribed chemical composition and is that which has been satisfactorily tested in the presence of the Surveyor in accordance with the Rules of Lloyd's Register."

Facilities for Inspection

2012 The manufacturer is to adopt a system of marking which will enable all material presented for inspection to be traced to the original cast, and, in the case of heat-treatable material, to the particular batch in which it was heat-treated; a batch comprises all material simultaneously heat-treated in one furnace load. The Surveyor must be given every facility for tracing all material to its respective casts and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of tests, he is to be furnished with two copies of the advice notes for his signature, one of which is to be forwarded by the manufacturer to the shipbuilder, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship is to be built.

Aluminium Alloys not made where Wrought

2013 Where the alloy is not made at the works where it is wrought, a certificate is to be supplied to the Surveyor stating the name of the maker of the material, also the numbers of the casts for reference to the books of the maker. The number of the cast is to be marked on each ingot or slab for the purpose of identification and the wrought material is also to be legibly stamped in two places with the manufacturer's name or trade mark and the place where finally wrought. The material is also to be stamped with numbers or identification marks by which it can be traced to the cast from which it was made.

Additional Tests

2014 In addition to the tests described hereafter, the material may be subjected to additional tensile tests at the discretion of the Surveyors.

Aluminium Alloys of other Chemical Composition or Mechanical Properties

2015 When desired by owners and builders, consideration will be given by the Committee to proposals for the use of alloys differing in chemical composition or mechanical properties from those provided for in the Rules.

Section 21

STANDARD TEST PIECES

Tensile Test Pieces

2101 The proof stress, the tensile strength and the ductility are to be determined from standard test pieces. The test for proof stress shall be carried out on each selected test piece either from a stress strain curve, by drawing a line parallel to the straight portion of the curve and distant from it by an amount representing the required maximum permanent elongation, thus determining the stress at which line and curve intersect; or by subjecting the test piece to the specified minimum proof stress and removing the load, when the test piece shall not have acquired a permanent elongation, measured by an extensometer, greater than that required by the Rules.

Plates and Sections

2102 Wherever practicable, the wrought surfaces are to be retained on two opposite sides of the test piece. The elongation is to be measured on a gauge length of 8 inches.

2103 For material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed $1\frac{1}{2}$ inches; for material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exceed 2 inches; for material less than ·375 inch in thickness the width is not to exceed $2\frac{1}{2}$ inches. In other respects the test pieces are to conform to standard test piece A. (*See* P 203.)

Alternatively, a test piece having a gauge length of 2 inches, a width of $\frac{1}{2}$ inch a minimum parallel length of $2\frac{1}{2}$ inches and a minimum radius at shoulder of 1 inch may be used.

Straightening of Test Pieces

2104 Any straightening of test pieces which may be required is to be done cold, and the test pieces shall not receive further heat treatment or mechanical working before being tested except by machining to shape.

Section 22

TESTS AND REQUIREMENTS FOR ALUMINIUM ALLOYS

Chemical Composition

2201 Plates, bars and sections where of non-heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than	0·10 per cent.
Magnesium	... ,, ,, ,,	5·50 per cent.
Iron	... ,, ,, ,,	0·75 per cent.
Silicon	... ,, ,, ,,	0·60 per cent.
Manganese	... ,, ,, ,,	1·00 per cent.
Chromium	... ,, ,, ,,	0·50 per cent.
Zinc	... ,, ,, ,,	0·10 per cent.

2202 Plates, bars and sections of heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than	0·10 per cent.
Magnesium	... ,, ,, ,,	1·50 per cent.
Iron	... ,, ,, ,,	0·60 per cent.
Silicon	... ,, ,, ,,	1·30 per cent.
Manganese	... ,, ,, ,,	1·00 per cent.
Chromium	... ,, ,, ,,	0·50 per cent.
Zinc	... ,, ,, ,,	0·03 per cent.

Bars and Sections

2203 May be formed by extrusion, rolling or by drawing.

Number of Tensile Tests : Plates

2204 Plates from the same cast shall be grouped in thickness for testing as follows:—

1·00 inch and over in thickness.
·75 inch and less than 1·00 inch.
·50 inch and less than ·75 inch.
·18 inch and less than ·50 inch.

One tensile test is to be taken from each group.

Number of Tensile Tests : Bars and Sections

2205 Sections from the same cast of non-heat-treatable material shall be grouped in weight as follows:—

Less than 1 lb. per foot.
Between 1 lb. and 9 lb. per foot, inclusive.
More than 9 lb. per foot.

One tensile test is to be taken from each group.

2206 For sections from the same cast of heat-treatable alloy, the groups will be the heat-treatment batches as defined in P 2012. One tensile test is to be taken from each group.

Tensile Tests : Plates and Sections

2207 The 0·1 per cent proof stress is not to be less than 8 tons per square inch. The tensile breaking strength is not to be less than 17 tons per square inch, and the elongation, measured on a gauge length of 8 inches, is not to be less than 10 per cent.

Alternatively, if the elongation is measured on a gauge length of 2 inches it is not to be less than 12 per cent.

Occasional Attendance at Works

2208 Where the Surveyor is not in constant attendance at the works, the manufacturer may, with the written authority of the Society, comply with all the prescribed requirements and furnish the Surveyor with a certificate to the effect that the Society's Rules for the testing of aluminium alloys for shipbuilding purposes have been complied with in the case of material submitted for approval. The Surveyor is then to examine the works history sheets for the material submitted and, if these are in order, to take check tensile tests from the materials. If the material in a single cast is of uniform thickness, two tensile test pieces are to be selected; if of different thicknesses two tensile test pieces are to be selected from the range of thicknesses presented. The test pieces are to be selected by the Surveyor from the plates or sections themselves, and not from shearings previously detached from them, and, when marked by the Surveyor for testing, they are to be followed, as far as is practicable, through the different stages of preparation until the tests are completed. If more than one cast is represented each cast is to be tested.

2209 Where the tests are unsatisfactory, the whole of the material from the cast is to be rejected and the Surveyor is to see that the Society's brand is satisfactorily defaced.

Section 23

RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

2301 All material from which rivets are manufactured is to be tested.

2302 Tensile tests are to be selected in accordance with P 2205 or P 2206.

2303 The 0·1 per cent proof stress is not to be less than 6 tons per square inch. The tensile breaking strength is not to be less than 14 tons per square inch, and the elongation is not to be less than 15 per cent if measured on a gauge length of eight times the diameter of the test piece (test piece B) or alternatively, not less than 18 per cent if measured on a gauge length of four times the diameter of the test piece (test piece C).

Dump Test

2304 Test pieces of a length and diameter equal to the full diameter of the bars, preferably cut from the same bars as the tensile tests shall, when cold, withstand being compressed to half their length in an axial direction without cracking.

Manufactured Rivets: Heat Treatment and Testing

2305 Rivets of non-heat-treatable alloys are to be supplied in the annealed condition.

Rivets of heat-treatable alloy are to be delivered to the shipyard in the heat treated condition specified. If, however, suitable facilities are available, then with the concurrence of the rivet manufacturer, the heat treatment may be carried out in the shipyard.

2306 Rivets selected by the Surveyor from bulk are to withstand the tests described in 2307.

2307 Test pieces, cut from the shanks of manufactured rivets, of a length and diameter equal to the full diameter of the shank, shall, when cold, withstand being compressed in an axial direction, without cracking, until the diameter is increased to 1·6 times the original diameter.

23rd July, 1953

APPENDIX

STEEL MANUFACTURERS

The following establishments have complied with the requirements for quality and testing of steel and have bee n recognised by the Committee.

Firms in Great Britain and Ireland.

The Firms marked with an asterisk have received the Committee's special approval for steel conforming to the requirements of P403.

Allen, Edgar, & Co., Ltd., Imperial Steel Works, Tinsley, Sheffield. (*Castings.*)
Alston Foundry Co., Ltd., Nent Force Foundry, Alston, Cumberland. (*Small castings.*)
*Appleby-Frodingham Steel Co., Branch of the United Steel Companies, Ltd., Scunthorpe, Lincs.,
Appleby Works. (*Plates and blooms.*)
Frodingham Works. (*Sections, bars and blooms.*)
Argus Foundry Ltd., Thornliebank, near Glasgow. (*Small castings.*)
Atlas Steel Foundry and Engineering Co., Ltd., The, Armadale, West Lothian. (*Castings.*)
Babcock & Wilcox, Ltd., Renfrew. (*Small castings.*)
Baird, Archibald, & Sons, Ltd., Hamilton, Lanarkshire. (*Castings.*)
Bairds & Scottish Steel, Ltd., Coatbridge, Lanarkshire,
Northburn Works. (*Ingots, billets, sections and bars.*)
Waverley Works. (*Sections and bars.*)
Victoria Works. (*Sections and bars.*)
Woodside Works. (*Sheets and strips.*)
Coats Works. (*Sections and bars.*)
Rochsolloch Works. (*Sections and bars.*)
Baker, J., & Bessemer, Ltd., Kilnhurst Steel Works, near Rotherham. (*Ingots and forgings.*)
Baker, W. A., & Co., Ltd., Westgate Works, Newport, Mon. (*Castings.*)
Barrow Steel Works, Ltd., Barrow-in-Furness, Lancashire.
Beardmore, William, & Co., Ltd., Parkhead, Glasgow. (*Castings, ingots, forgings, billets and blooms.*)
Blackett, Hutton & Co., Ltd., Cleveland Steel Foundry, Guisborough, Yorkshire. (*Castings.*)
Blair, George, & Co., Ltd., Armond Carr Works, Tow Law, Co. Durham. (*Castings.*)
Bond's Foundry Co., Tow Law, Co. Durham. (*Small castings.*)
Bonnington Castings, Ltd., Leith. (*Small castings.*)
Braby, Fredk., & Co., Ltd., Eclipse Iron and Galvanizing Works, Glasgow. (*Rolling mills for plates up to $\frac{1}{4}$ inch in thickness.*)
British Rolling Mills, Ltd., Brymill Works, Tipton, Staffs. (*Cold drawn bright bars.*)
Brockhouse Castings, Ltd., Wednesfield, Wolverhampton. (*Small castings.*)
Brown Bayley Steels, Ltd., Sheffield. (*Ingots, forgings and bars.*)
Brown, The David, Foundries Co., Penistone, Yorks. (*Castings.*)
Brown, Lenox & Co., Ltd., Pontypridd. (*Castings.*)
Cargo Fleet Iron Co., Ltd., Cargo Fleet, Middlesbrough. (*Sections and bars.*)
Carntyne Steel Castings Co., Ltd., Moorpark, Renfrew. (*Castings.*)
Catton & Co., Ltd., Yorkshire Steel Foundry, Hunslet, Leeds. (*Castings.*)
Clyde Alloy Steel Co., Ltd., Craigneuk Works, Flemington, Motherwell. (*Castings.*)
Coghlan Forge & Rolling Mills, Ltd., and Coghlan Bright Steel, Ltd., Hunslet Forge, Leeds. (*Rolling mills for bars; forgings.*)

*Colvilles Ltd.,
Dalzell Steel and Iron Works, Motherwell, Lanarkshire. (*Plates, sections, bars and blooms.*)
Clydebridge Steel Works, Cambuslang, near Glasgow. (*Plates.*)
Glengarnock Iron and Steel Works, Glengarnock, Ayrshire. (*Sections and bars.*)
*Consett Iron Co., Ltd., Blackhill, Durham.
Consett Iron Co., Ltd., (Jarrow Mill), Blackett Street, Jarrow-on-Tyne. (*Rolling mills for sections and rounds.*)
Crofts (Engineers), Ltd., Thornbury, Bradford. (*Castings.*)
Cruikshank & Co., Ltd., Denny Iron Works, Denny, Stirlingshire. (*Small castings.*)
Curran Steels Ltd., Cardiff. (*Castings.*)
Darlington Forge Ltd., Albert Hill, Darlington. (*Castings, ingots and forgings.*)
Darlington & Simpson, Rolling Mills Ltd., Darlington. (*Rolling mills for small sections and bars.*)
Davy & United Roll Foundry, Ltd., Empire Works, Haverton Hill, Billingham, Co. Durham. (*Castings.*)
*Dorman, Long (Steel) Ltd.,
Britannia Works, Middlesbrough. (*Rolling mills for sections and bars.*)
Cleveland Works, South Bank, Middlesbrough. (*Sections and bars.*)
Lackenby Works, Middlesbrough. (*Ingots.*)
Redcar Works, Redcar. (*Plates.*)
English Steel Casting Corporation, Ltd., Grimesthorpe Works, Sheffield. (*Ingots and castings.*)
English Steel Forge & Engineering Corporation Ltd.,
English Steel Rolling Mills Corporation Ltd.,
River Don Works, Sheffield. (*Forgings, plates, billets and bars.*)
North St. Works, Openshaw, Manchester. (*Forgings, bars, plates up to $\frac{1}{2}$ inch in thickness.*)
Etna Iron and Steel Co., Ltd., Motherwell, Lanarkshire. (*Rolling mills for sections and bars.*)
Firth, Thomas, & John Brown, Ltd.,
Atlas Works, Sheffield. (*Ingots, forgings, rolled bars and billets.*)
Norfolk Works, Sheffield. (*Castings and rolled strips.*)
Castings Division, Scunthorpe. (*Castings.*)
Firth Vickers Stainless Steels, Ltd., Sheffield. (*Rolling mills for plates, bars and sections; also castings.*)
Fox, Samuel, & Co., Ltd., Stocksbridge Works, near Sheffield. (*Ingots.*)
Glanmor Foundry Co., Llanelly. (*Castings.*)
Guest, Keen & Nettlefolds (South Wales), Ltd., Cardiff.
Castle Works. (*Rolling mills for bars and strips.*)
Tremorfa Works. (*Rolling mills for bars and sections.*)
Guest Keen Iron & Steel Co., Ltd., East Moors, Cardiff. (*Ingots, blooms and billets; sections and bars.*)
Hadfields, Ltd., East Hecla Works, Sheffield. (*Ingots, blooms, billets, forgings, bars, special sections and castings.*)
Halesowen Steel Co., Ltd., The, Halesowen, near Birmingham. (*Cold drawn bright bars.*)
Hamilton, A., & Sons, Ltd., Victoria Foundry, East Moors, Cardiff. (*Small castings.*)
Head, Wrightson & Co., Ltd., Thornaby-on-Tees. (*Castings.*)
Hopkinsons, Ltd., Britannia Works, Huddersfield, Yorkshire. (*Castings.*)
Hyde, Robert, & Son, Ltd., North Stafford Steel Works, Stoke-on-Trent. (*Small castings.*)
Clarendon Works at Chesterfield. (*Small castings.*)
Industrial Steels, Ltd., Stevenson Road, Sheffield. (*Ingots, blooms, billets and bars.*)
Jackson, Ltd., Salford, Manchester. (*Castings.*)
Jarrow Metal Industries, Ltd., Western Road, Jarrow. (*Castings.*)
Jessop, W., & Sons, Ltd., Brightside Works, Sheffield. (*Ingots, blooms, bars, forgings and castings.*)
Jopling, E., & Sons, Pallion, Sunderland. (*Castings.*)
Kirkstall Forge Engineering, Ltd., Leeds. (*Rolling mills for bars, forgings and heavy drop forgings.*)
Kryn & Lahy (1928), Ltd., Letchworth, Hertfordshire. (*Castings.*)
Lake & Elliot, Ltd., Engineers and Founders, Braintree, Essex. (*Small castings.*)
Lanarkshire Steel Co., Ltd., Motherwell, Lanarkshire. (*Sections.*)

Lancashire Steel Corporation, Ltd., Irlam, Manchester. (*Billets, bars, sections and castings.*)
Pearson & Knowles Works, Warrington, Lancs. (*Rolling mills for sections and bars.*)
Leyland Motors, Ltd., Farington Foundries, Leyland. (*Castings.*)
Lilleshall Co., Ltd., St. George's, near Oakengates, Shropshire. (*Rolling mills for sections and bars.*)
Lloyd, F. H., & Co., Ltd., James Bridge, near Wednesbury, Staffordshire. (*Castings.*)
Lloyds (Burton) Ltd., Wellington Works, Burton-on-Trent, Derbyshire. (*Castings.*)
Lysaght's, John, Scunthorpe Works Ltd., Scunthorpe, Lincs. (*Ingots, billets and slabs.*)
Martins (Dundyvan), Ltd., Coatbridge, Lanarkshire. (*Rolling mills for sections.*)
Mills, Exors. of James, Ltd., Bredbury Steel Works & Rolling Mills, near Stockport. (*Rolling mills for bars.*)
Monks, Hall & Co., Ltd., Warrington. (*Rolling mills for bars.*)
National Steel Foundry (1914), Ltd., The, Kirkland Works, Leven, Fifeshire. (*Castings.*)
North British Steel Foundry, Ltd., The, Balbardie Steel Works, Bathgate. (*Small castings.*)
Osborn, Samuel, & Co., Ltd., Clyde Steel Works, Sheffield. (*Castings.*)
Park Gate Iron & Steel Co., Ltd., Rotherham, Yorkshire.
Parker Foundry (1929) Ltd., "Tropenas" Steel Works, Derby. (*Small castings.*)
Partridge, Jones & John Paton, Ltd., Pontymister Foundry, Risca, nr. Newport, Mon. (*Castings.*)
Patent Shaft & Axletree Co., Ltd., Wednesbury, Staffordshire.
Raine & Co., Ltd., Delta Iron & Steel Works, Derwenthaugh, Newcastle-on-Tyne. (*Rolling mills for sections and bars.*)
Redheugh Iron & Steel Co. (1936), Ltd., Teams, Gateshead-on-Tyne. (*Rolling mills.*)
Renton & Fisher, Ltd., Hopetoun Steel Works, Bathgate. (*Castings.*)
Robertson, Wm., Ltd., Latchford, Warrington. (*Cold drawn bright bars.*)
Round Oak Steel Works, Ltd., Brierley Hill, Staffordshire. (*Sections and bars.*)
Ryder Brothers, Ltd. (Beehive Steel Foundry), Bolton. (*Small castings*).
Sanderson Brothers & Newbould Limited, Sheffield. (*Ingots, billets and bars.*)
Shaw, W., & Co., Ltd., Wellington Cast Steel Foundry, Middlesbrough. (*Castings.*)
Shelton Iron, Steel & Coal Co., Ltd., Stoke-on-Trent. (*Ingots, billets, bars and sections.*)
Skinningrove Iron Co., Ltd., Skinningrove Iron Works, Saltburn-by-the-Sea. (*Sections and bars.*)
Smith & McLean, Ltd.,
Gartcosh Works, Gartcosh, Lanarkshire. (*Thin plates.*)
Milnwood Works, Mossend, Lanarkshire. (*Thin plate and light sections.*)
*South Durham Steel & Iron Co., Ltd., West Hartlepool. (*Plates.*)
Springfield Steel Co., Ltd., 1323, London Road, Glasgow. (*Castings.*)
Steel Company of Scotland, Ld.,
Blochairn Works, Glasgow. (*Plates.*)
Hallside Works, Newton, Glasgow. (*Castings and sections.*)
Steel Company of Wales, Ld.,
Abbey Works, Port Talbot. (*Ingots, plates and strips.*)
Margam Works, Port Talbot. (*Ingots.*)
Port Talbot Works, Port Talbot. (*Ingots, sections and bars.*)
Steel, Peech & Tozer, Sheffield. (*Ingots, blooms, forgings, rivet and stay bars.*)
Stewarts & Lloyds, Ltd.,
Clydesdale Steel and Tube Works, Mossend, Lanarkshire. (*Ingots, billets, slabs and strips for tubes.*)
Corby Open Hearth Works. (*Ingots, billets, slabs, strips for tubes and electric resistance welded tubes.*)
Alfred Hickman Branch, Bilston, Staffordshire. (*Tube ingots, rolled billets and bars.*)
Landore, S. Wales. (*Seamless tubes for all purposes.*)
Tollcross Works, Tollcross, Glasgow. (*Castings.*)
Stockton Steel Foundry Co., Ltd., Stockton-on-Tees. (*Castings.*)
Summersons Foundries, Ltd., Darlington. (*Small castings.*)
Taylor Bros. & Co., Ltd., Trafford Park Steel Works, Manchester. (*Ingots.*)
Thomas, Richard, & Baldwins, Ltd., Redbourne Works, Scunthorpe, Lincolnshire. (*Ingots, billets, bars and slabs.*)
United Strip and Bar Mills, The Ickles, Sheffield. (*Rolling mills for bars.*)

Vickers-Armstrongs, Ltd.,
Barrow-in-Furness. (*Castings and forgings.*)
Elswick Works, Elswick, Northumberland. (*Castings.*)
Washington Steel Foundries, Ltd., Washington Station S.O., Co. Durham. (*Castings.*)
Weir, G. & J., Ltd., Coltness Foundries, Newmains, Lanarkshire. (*Castings.*)
West Lothian Steel Foundry Co., Ltd., Harthill Works, Armadale, West Lothian. (*Small castings.*)
Whitehead Iron & Steel Co., Ltd., Courtybella Works, Newport, Mon. (*Rolling mills for strips, bars and sections.*)
Whitehead Thomas Bar and Strip Co., Ltd., Redbourne Works, Scunthorpe, Lincs. (*Rolling mills for bars and strips.*)
Williams, John, & Co. (Wishaw), 1922, Ltd., Excelsior Iron & Steel Works, Craigneuk, Motherwell, Lanarkshire. (*Rolling mills for thin plates.*)
"Wilson's Forge" (1929) Ltd., Bishop Auckland, Co. Durham. (*Castings.*)
Wolsingham Steel Co., Ltd., Wolsingham, Co. Durham. (*Castings and forgings.*)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ALPHABETICALLY ARRANGED)

The Works marked with an asterisk have received the Committee's special approval for steel conforming to the requirements of P 403.

Note: The place of residence of the Surveyor giving attendance at each works is shown in parentheses.

A.1. Iron & Steel Foundry, Ltd., Vancouver, Canada. (*Small castings.*) (VANCOUVER.)

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*) (GENOA.)

Administration Séquestre des Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen (Saar). (*Castings, ingots, billets, bars and forgings.*) (HILBRINGEN-SAAR.)

Aichi Steel Works, Ltd.,
- Aichi Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)
- Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)

d'Alais, Compagnie des Mines Fonderies et Forges, Tamaris (Gard), France. (*Castings.*) (MARSEILLES.)

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars and angles.*) (TORONTO.)

Allard, Usines & Acieries, Société Anonyme, Mont-sur-Marchienne, near Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Allard, Usines & Acieries, Société Anonyme, Turnhout, Belgium. (*Small castings.*) (ANTWERP.)

Alves, Alfredo, & Cia. (Filhos), Amadora, Portugal. (*Castings.*) (LISBON.)

Amagasaki Iron & Steel Manufacturing Co., Ltd., Kure Works, Kure, Japan. (*Ingots and castings.*) (SHIMONOSEKI.)

Amagasaki Steel Works, Ltd., Amagasaki, Japan. (*Ingots, plates, sections and bars.*) (KOBE.)

American Locomotive Co., Railway Steel Spring Division, Latrobe, Pa., U.S.A. (*Ingots.*) (PITTSBURGH, PA.)

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*) (CLEVELAND, O.)

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*) (MALMÖ.)

Ansaldo-Fossati, Stabilimento Meccanico Metallurgico Genovese, S.p.A., Genoa-Sestri, Italy. (*Forgings.*) (GENOA.)

"ARBED," Aciéries Reunies de Burbach-eich-Dudelange,
- Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*) (ANTWERP.)
- Division de Dudelange, Greisendahl, Luxembourg. (*Rolling mills for plates up to 8mm. in thickness.*) (ANTWERP.)
- Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*) (ANTWERP.)
- Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*) (ANTWERP.)
- Division de Burbach, Sarrebruck,
  - Burbach Works. (*Ingots, billets and sections.*) (HILBRINGEN-SAAR.)
  - Hostenbach Works. (*Plates.*) (HILBRINGEN-SAAR.)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Atlas Steels, Ltd., Welland, Ontario, Canada. (*Ingots and bars.*) (TORONTO.)

Aubert et Duval, Anciens Ets., Acieries des Ancizes, Puy de Dome, France. (*Ingots, rolled bars and forgings.*) (ST. ETIENNE.)

August Thyssen-Hütte, A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections and bars.*) (DUSSELDORF.)

Australian Electric Steel Ltd., Alexandria, Sydney, N.S.W. (*Small castings.*) (SYDNEY.)

*Australian Iron & Steel, Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*) (SYDNEY.)

*Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*) (STOCKHOLM.)

Azuma Steel Works, Ltd.,
- Azuma Plant, Tokyo, Japan. (*Ingots for plate.*) (YOKOHAMA.)
- Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*) (YOKOHAMA.)

Babcock & Wilcox, Sociedad Espanola de Construcciones,
Head Office: Calle Ercilla 1, Bilbao, Spain.
Works: Galindo-San Salvador Del Valle, Vizcaya, Spain. (*Castings, ingots and forgings.*) (BILBAO.)

Bach & Co., Nordische Stahlwerke, Neumunster, Germany. (*Castings.*) (KIEL.)

Bakker, N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*) (ROTTERDAM.)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*) (BILBAO.)

Baume et Marpent, Société Anonyme,
- Division de Baume, Haine Saint Pierre, Belgium. (*Small castings.*) (ANTWERP.)
- Division de Marpent, Marpent, Nord, France. (*Castings.*) (VALENCIENNES.)

Baume, Société Anonyme des Forges et Laminoirs de, Haine St. Pierre, Belgium. (*Ingots, bars and sections.*) (ANTWERP.)

Bergische Stahlindustrie K. G., Remscheid, Germany. (*Castings.*) (DUSSELDORF.)

Bertoli fu Rodolfo, Società Anonima Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*) (TRIESTE.)

Bethlehem Pacific Coast Steel Corporation,
- Los Angeles 54, Cal., U.S.A. (*Round bars.*) (LOS ANGELES.)
- Seattle, Wash., U.S.A. (*Sections and bars.*) (SEATTLE.)
- South San Francisco, Cal., U.S.A. (*Ingots, small sections and bars.*) (SAN FRANCISCO.)

Bethlehem Steel Co.,
Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*) (PHILADELPHIA.)
Buffalo, N.Y., U.S.A. (CLEVELAND, O.)
Johnstown Plant, Johnstown, Pa., U.S.A. (PITTSBURGH.)
Lebanon, Pa., U.S.A. (*Rolling mills for bars.*) (PHILADELPHIA.)
*Sparrows Point, Md., U.S.A. (*Plates.*) (BALTIMORE.)
Steelton, Pa., U.S.A. (*Forgings and castings.*) (PHILADELPHIA.)

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Melting furnaces and forge.*) (GOTHENBURG.)

Blanc-Misseron, Société Francaise des Acieries de, Quievrechain, Nord, France. (*Ingots and castings.*) (VALENCIENNES.)

Bochumer Verein Guss-Stahlwerk A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*) (DUSSELDORF.)

Boel, Usines Gustave, Soc. An., La Louvière, Belgium. (*Ingots, forgings, castings, plates and bars.*) (ANTWERP.)

Bofors, Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*) (GOTHENBURG.)

Böhler, Gebr. & Co., Aktiengesellschaft, Vienna, Austria. *Works :* Kapfenberg, Styria. (*Ingots, castings, forgings and bars.*) (SALZBURG.)

Bolzaneto, Acciaieria e Ferriera di, Genoa, Italy. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*) (GENOA.)

Bolzano, Società per Azioni Acciaierie di, Bolzano, Italy. (*Castings, ingots, billets, bars and forgings.*) (TRIESTE.)

Boom, Travaux Metalliques de, Société Anonyme, Boom, Belgium. (*Small castings.*) (ANTWERP.)

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*) (HANOVER.)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*) (STOCKHOLM.)

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*) (SYDNEY, N.S.W.)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves, Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*) (RIO DE JANEIRO.)

Breda Fonderia, Forgia Macchine Industriali, Sesto San Giovanni, Milan, Italy. (*Castings and forgings.*) (GENOA.)

Breda Siderurgica Società per Azioni, Sesto San Giovanni, Milan, Italy. (*Ingots and sections.*) (GENOA.)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*) (DUSSELDORF.)

Brescia, Acciaieria e Tubificio di, Società Anonima, Brescia, Italy. (*Ingots, sections and bars, castings, weldless drawn or water gas welded tubular material.*) (GENOA.)

Broken Hill Proprietary Co., Ltd.,
*Iron & Steel Works, Newcastle, N.S.W. (*Plates, bars, sections and castings.*) (NEWCASTLE, N.S.W.)
Steel Foundry, Whyalla, S. Australia. (*Castings.*) (WHYALLA.)

Brugeoise et Nicaise & Delcuve, Société Anonyme La, St. Michel-lez-Bruges, Belgium. (*Castings.*) (ANTWERP.)

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

Burn & Co., Ltd., Howrah, India. (*Small castings.*) (CALCUTTA.)

Caleotto, Acciaieria e Ferriera del, Società Anonima, Lecco, Italy. (*Ingots, bars, small sections and small forgings.*) (GENOA.)

Canada Foundries & Forging, Ltd., Welland, Ontario, Canada. (*Forgings.*) (TORONTO.)

Canadian Car & Foundry, Steel Foundry Division, Longue Pointe, Montreal, P.Q., Canada. (*Castings.*) (MONTREAL.)

Canadian Sumner Iron Works Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

Canadian Tube & Steel Products, Ltd., 5765, Hamilton Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*) (MONTREAL.)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*) (MONTREAL.)

Cantieri Del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*) (GENOA.)

Cantieri Navali Riuniti. *Head Office* : Genoa. *Works :* Cantiere Navale ed Officine Meccaniche di Ancona. (*Small castings.*) (GENOA.)

*Central Iron & Steel Co., Harrisburg, Pa., U.S.A. (*Rolling mills.*) (PHILADELPHIA.)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell'Ossola-Villadossola, Italy. (*Castings.*) (GENOA.)

*Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi, Belgium. (*Ingots and plates.*) (ANTWERP.)

Chatillon-Commentry et Neuves Maisons, Compagnie, Usines Saint Jacques de Montlucon, Commentry, Montlucon, France. (*Castings, ingots, forgings, sheets and sections.*) (ST. ETIENNE.)

Chiers, Société des Hauts-Forneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, sections and bars.*) (VALENCIENNES.)

Christiania Spigerverk, Oslo, Norway. (*Ingots and bars, also rivet bars.*) (OSLO.)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*) (ANTWERP.)

Cobianchi, Metallurgica Vittorio, Soc. Anon. *Head Office :* Milan, Italy. *Works :* Omegna (Novara.) (*Castings.*) (GENOA.)

*Cockerill, Société Anonyme John. *Works :* Seraing and Grivegnée, Belgium. (*Ingots and plates.*) (ANTWERP.)

"Cogne," Società Anonima Nazionale. *Head Office:* Turin. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*) (GENOA.)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*) (CLEVELAND, O.)

Columbia-Geneva Steel, (Division United States Steel Co.), Torrance, Cal., U.S.A. (*Round bars and sections.*) (LOS ANGELES.)

Commentry-Fourchambault et Decazeville, Société Anonyme de, Imphy (Nievre), France. (*Ingots, forgings, bars and sections.*) (ST. ETIENNE.)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*) (NEWCASTLE, N.S.W.)

Compagnie des Ateliers et Forges de la Loire,
*Usines de St. Etienne, St. Etienne (Loire), France. (ST. ETIENNE.)
Usines d'Unieux, Unieux (Loire), France. (*Forgings.*) (ST. ETIENNE.)

Compagnie Generale des Aciers, Société Anonyme, Thy-le-Chateau, Belgium. (*Castings.*) (ANTWERP.)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*) (BILBAO.)

Constructions Mecaniques, Société Francaise de, (Anciens Etablissements Cail), Denain, Nord, France. (*Castings, ingots, forgings, blooms, bars and sheets.*) (VALENCIENNES.)

Cornigliano S.p.A., Genoa, Italy. (*Ingots and plates.*) (GENOA.)

*Cornigliano, Società Italiana Acciaierie. (*Head Office:* Genoa; *Works:* Genoa-Cornigliano.) (*Ingots, forgings, castings, plates and sections.*) (GENOA.)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Crucible Steel Company of America, Pittsburgh Crucible Division, Midland, Pa., U.S.A. (PITTSBURGH.)

Daido Steel Co., Ltd.,
Hoshizaki Works, Nagoya, Japan. (*Ingots.*) (KOBE.)
Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Dalmine, Stabilimenti di, Società Anonima, Dalmine (Bergamo), Italy. (*Weldless rolled or drawn tubes, hollow pillars and davits.*) (GENOA.)

*Danske, (Det), Staalvalsevaerk A/S, Frederiksvaerk, Denmark. (*Plates, sections and bars.*) (COPENHAGEN.)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*) (WINTERTHUR.)

De Wendel et Cie., S/A., Hayange, Moselle, France.
*Usine de Fenderié. (*Plates.*) (VALENCIENNES.)
Usine de St. Jacques. (*Sections.*) (VALENCIENNES).

*Degerfors Jernverks Aktiebolag, Degerfors, Sweden. (*Ingots, plates, sections and bars.*) (GOTHENBURG.)

Deusto, Sociedad Anonima Talleres de, Deusto, Bilbao, Spain. (*Castings.*) (BILBAO.)

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*) (AMSTERDAM.)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*) (HILBRINGEN-SAAR.)

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein, Germany. (*Castings.*) (AUGSBURG.)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Dominion Foundries & Steel Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*) (TORONTO.)

Dominion Iron & Steel, Ltd., a subsidiary of Dominion Steel & Coal Corporation, Ltd., Sydney, Nova Scotia. (*Ingots, billets and sections.*) (HALIFAX, N.S.)

Dortmund - Hoerder Hüttenunion, A.G., Dortmund, Germany.
*Dortmund-Hoerde Works. (*Ingots, plates, sections, bars, forgings and castings.*) (DORTMUND.)
Dortmund Works. (*Bars, sections and forgings.*) (DORTMUND.)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen, Norway. (*Small castings.*) (OSLO.)

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets and small sections.*) (DURBAN.)

Duro-Felguera, Sociedad Metalurgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*) (BILBAO.)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars.*) (BILBAO.)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*) (BILBAO.)

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*) (HANOVER.)

Eisenwerke Mülheim - Meiderich Aktiengesellschaft, Mülheim-Ruhr, Germany. (*Castings.*) (DUSSELDORF.)

Empire Steel Corporation, Mansfield, O., U.S.A. (*Ingots.*) (PITTSBURGH.)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*) (CLEVELAND, O.)

Española de Construccion Naval, Sociedad.
Works: Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*) (BILBAO.)
Works: Sestao, near Bilbao, Spain. (*Small castings, ingots and forgings.*) (BILBAO.)
San Carlos Factory, San Fernando, Cadiz, Spain. (*Castings.*) (CADIZ.)

l'Est, Société des Aciers Fins de, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*) (VALENCIENNES.)

Etablissements J. J. Carnaud et Forges de Basse-Indre, Basse-Indre, Loire-Inférieure, France. (*Castings.*) (NANTES.)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*) (BILBAO.)

Fabrica Italiana Tubi, Società Anonima, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*) (GENOA.)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen.)

Works : Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*) (STOCKHOLM.)

Works : Forsbacka. (*Blooms, billets, tubes and forged and rolled bars.*) (STOCKHOLM.)

Works : Horndal. (*Bars and angles.*) (STOCKHOLM.)

Works : Osterbybruk. (*Castings, forgings and rolling mill for bars.*) (STOCKHOLM.)

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*) (GENOA.)

Fairmount Steel Corporation, Philadelphia, Pa., U.S.A. (*Ingots and forgings.*) (PHILADELPHIA.)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works :* Milan, Italy. (*Weldless rolled or drawn tubes.*) (GENOA.)

*"Concordia." *Works :* Sesto San Giovanni. (*Rolling mills for plates.*) (GENOA.)

"Unione." *Works :* Sesto San Giovanni. (*Ingots, sections, bars, forgings and castings.*) (GENOA.)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*) (CLEVELAND, O.)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections, also seamless and welded tubes.*) (GENOA.)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings and forgings.*) (GENOA.)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*) (CLEVELAND, O.)

Firminy, Société Anonyme des Aciéries et Forges de, Usine des Dunes Leffrinckoucke, Boîte Postale No. 41, Malo-les-Bains, France. (*Ingots, billets, blooms, bars and forgings.*) (VALENCIENNES.)

Fischer, Société Anonyme des Aciéries ci-devant Georges, Schaffhouse, Switzerland. (*Castings.*) (WINTERTHUR.)

Fives-Lille, Compagnie de, Société Anonyme, Fives-Lille (Nord), France. (*Ingots, castings and forgings.*) (VALENCIENNES.)

Fuji Iron & Steel Co., Ltd.

**Works :* Hirohata, Himeji City, Japan. (*Ingots, billets and plates.*) (KOBE.)

Works : Kamaishi, Japan. (*Sections and bars.*) (YOKOHAMA.)

Works : Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*) (YOKOHAMA.)

Works : Muroran, Hokkaido, Japan. (*Billets, sections and bars.*) (YOKOHAMA.)

Fujinagata Shipbuilding Co., Ltd., Osaka, Japan. (*Castings and forgings.*) (KOBE.)

Fundiciones Escorsa S.A., Pi y Margall, 2- Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*) (BARCELONA.)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Geneva Steel Company (United States Steel Corp. Subsidiary), Geneva, Utah, U.S.A. (*Plates.*) (LOS ANGELES.)

Gennevilliers, Aciéries de, Gennevilliers, Seine, France. (*Castings.*) (VALENCIENNES.)

Gilson, Société Anonyme des Usines, La Croyère (Bois d'Haine), Belgium. (*Ingots, blooms, sections, rivet bars and forgings.*) (ANTWERP.)

Gorizia, Società Anonima Fonderie Officine di, Gorizia, Italy. (*Small castings.*) (TRIESTE.)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza, Italy. (*Castings, bars, sections and forgings.*) (TRIESTE.)

Grosse Forge, Aciéries et Ateliers de, Maurice Dembiermont & Cie., Hautmont (Nord), France. (*Forgings.*) (VALENCIENNES.)

Guérigny, Forges Nationales de la Chaussade à Nièvre, France. (*Ingots, bars and forgings.*) (ST. ETIENNE.)

Gussstahlwerk Gelsenkirchen A.G., Gelsenkirchen, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*) (DORTMUND.)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*) (DUSSELDORF.)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*) (SYDNEY.)

Hahn'sche Werke, A.G., Duisburg-Grossenbaum, Germany. (*Bars.*) (DUSSELDORF.)

Hainaut, Société Anonyme Usines Metallurgiques du, Couillet, Belgium. (*Ingots, blooms, bars, forgings and castings.*) (ANTWERP.)

Haine St. Pierre et Lesquin, Société Anonyme, Aciéries de, Haine St. Pierre, Belgium. (*Castings.*) (ANTWERP.)

Haine-St. Pierre et Lesquin, Société Anonyme des Aciéries de, Lesquin-lez-Lille (Nord), France. (*Castings.*) (VALENCIENNES.)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small forgings and castings.*) (YOKOHAMA.)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Castings and bars.*) (STOCKHOLM.)

Harima Shipbuilding & Engineering Co., Ltd., Aioi, Japan. (*Castings and forgings.*) (KOBE.)

Hauts-Fourneaux, Société Anonyme des, Forges et Aciéries de Pompey,

Division Dieulouard, France. (*Ingots, blooms, billets and bars.*) (VALENCIENNES.)

Usines de Pompey, Meurthe et Moselle, France. (*Ingots, plates, angles and round bars.*) (VALENCIENNES.)

Usines du Manoir à Pitres, Eure, France. (*Castings.*) (ROUEN.)

Helsingors Skibsvaerft-og Maskinbyggeri A/S, Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*) (NANTES.)

Henricot, Usines Emile, Court St. Etienne, Belgium. (*Castings.*) (ANTWERP.)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*) (VALENCIENNES.)

Hitachi, Ltd.,

Hitachi Works, Hitachi, Japan. (*Castings.*) (YOKOHAMA.)

Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)

Mito Works, Mito-Shi, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Yasugi Works, Yasugi, Japan. (*Ingots and bars.*) (KOBE.)

Hitachi Shipbuilding Co., Ltd., Chikko Dockyard, Osaka, Japan. (*Castings and forgings.*) (KOBE.)

Hitachi Shipbuilding & Engineering Co., Ltd., Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*) (KOBE.)

Hüttenwerk Haspe, A.G., Hagen-Haspe (Dortmund), Germany. (*Ingots, plates, bars and sections.*) (DORTMUND.)

Hüttenwerk Ilsede-Peine, A.G., Peine, Germany. (*Ingots, billets, sections and bars.*) (HANOVER.)

*Hüttenwerk Oberhausen A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerk Rheinhausen A.G., Rheinhausen, Germany. (*Bars and sections only.*) (DUSSELDORF.)

*Hüttenwerk Salzgitter A. G., Salzgitter - Drütte, Germany. (*Ingots and plates.*) (HANOVER.)

Iino Sangyo K.K., Maizuru Dockyard, Maizuru, Japan. (*Forgings and castings.*) (KOBE.)

Ilva Alti Forni e Acciaierie d'Italia. *Head Office :* Genoa, Italy.

Stabilimento di Bagnoli. (*Ingots, sections and bars.*) (NAPLES.)

Stabilimento di Genoa-Voltri. (*Rivets.*) (GENOA.)

Stabilimento di Lovere. (*Sections, bars, castings and forgings.*) (GENOA.)

Stabilimento di Marghera. (*Castings, also rolling mills for small sections and bars.*) (TRIESTE.)

Stabilimento di Novi Ligure. (*Sections, bars and plates.*) (GENOA.)

Stabilimento di Porto Vecchio de Piombino. (*Ingots, blooms, sections and bars.*) (GENOA.)

*Stabilimento di Servola. (*Ingots and plates.*) (TRIESTE.)

Stabilimento di Torre Annunziata, Centrale. (*Ingots, sections and bars.*) (NAPLES.)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*) (CALCUTTA.)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W., Australia. (*Castings.*) (SYDNEY.)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*) (BARCELONA.)

*Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*) (CLEVELAND, O.)

Isaacson Iron Works, P.O. Box 3028, Seattle 14, Wash., U.S.A. (*Ingots.*) (SEATTLE.)

Ishikawajima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*) (ANTWERP.)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Forgings.*) (YOKOHAMA.)

Japan Steel Works Ltd.

Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*) (SHIMONOSEKI.)

*Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*) (YOKOHAMA.)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*) (ANTWERP.)

Jeumont, Forges et Ateliers de Constructions Electriques de, Jeumont (Nord), France. (*Castings.*) (VALENCIENNES.)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A. (PITTSBURGH.)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*) (LOS ANGELES.)

Kanthal, A/B, Hallstahammar, Sweden. (*Castings and bars.*) (STOCKHOLM.)

Kanto Special Steel Works, Ltd., Yokohama, Japan. (*Forgings.*) (YOKOHAMA.)

Kanto Steel Manufacturing Co., Ltd., Shibukawa Plant, Toyoaki-Mura, Gunma Prefecture, Japan. (*Ingots and rivet bars.*) (YOKOHAMA.)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Steel Corporation.

Chiba Iron & Steel Mill, Chiba. (*Slabs for plates.*) (YOKOHAMA.)

*Fukai Plant, Kobe. (*Plates.*) (KOBE.)

Hyogo Plant, Kobe. (*Castings and forgings.*) (KOBE.)

Kilby Steel Co., Furnace Division, Anniston, Alabama, U.S.A. (*Ingots.*) (MOBILE.)

Klöckner - Georgsmarienwerke A.G., Osnabrück, Germany. (*Ingots, bars, forgings and castings.*) (HANOVER.)

Kobe Steel Works, Ltd., Kobe, Japan. (*Castings and forgings.*) (KOBE.)

Kobe Steel Works, Ltd., Takasago Plant, Arai, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*) (MALMO.)

Kohlswa Jernverks Aktiebolag. (*Melting furnaces, foundry forge and rolling mills for bars and small sections* at Kolsva, Sweden.) (STOCKHOLM.)

Kokko Chain & Machinery Manufacturing Co., Ltd., Osaka, Japan. (*Angles, bars and castings.*) (KOBE.)

Komatsu Manufacturing Co., Ltd., Komatsu, Japan. (*Castings.*) (KOBE.)

*Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*) (AMSTERDAM.)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*) (SHIMONOSEKI.)

La Maquinista Terrestre y Maritima, S.A., Barcelona, Spain. (*Castings and forgings.*) (BARCELONA.)

*Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*) (VALENCIENNES.)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Leonard-Giot, Société Anonyme Usines & Aciéries, Marchienne-au-Pont, Belgium. (*Castings.*) (ANTWERP.)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Rolling mill for bars.*) (GOTHENBURG.)

Liguri, Società Anonima Fonderie Acciaierie, Genoa-Sampierdarena, Italy. (*Small castings.*) (GENOA.)

Llodio, Ltda., Aceros de, Llodio, near Bilbao, Spain. (*Small castings, ingots and forgings.*) (BILBAO.)

Lorraine-Escaut S.A.,

Departement Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*) (VALENCIENNES.)

*Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle), France. (*Sections and plates.*) (VALENCIENNES.)

Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle), France. (*Ingots, blooms, bars and sections.*) (VALENCIENNES.)

Usine de Sedan, Sedan (Ardennes), France. (*Plates.*) (VALENCIENNES.)

Usine de Thionville, Thionville (Moselle), France. (*Forgings.*) (VALENCIENNES.)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*) (LOS ANGELES.)

Louvroil-Montbard-Aulnoye, Société Anonyme, Aulnoye (Nord), France. (*Weldless rolled or drawn tubes.*) (VALENCIENNES.)

*Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*) (PHILADELPHIA.)

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Castings.*) (BILBAO.)

Lynn Macleod Metallurgy Ltd., Thetford Mines, P.Q., Canada. (*Castings.*) (MONTREAL.)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*) (KOBE.)

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*) (ISTANBUL.)

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*) (DURBAN.)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*) (MONTREAL.)

*Mannesmann Hüttenwerke A.G., Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Marine et d'Homécourt, Compagnie des Forges et Aciéries de la, St. Chamond (Loire), France. (ST. ETIENNE.)

Maritime Steel and Foundries, Ltd., New Glasgow, Nova Scotia. (*Small castings.*) (HALIFAX, N.S.)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais, France. (*Castings.*) (VALENCIENNES.)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Gier (Loire), France. (ST. ETIENNE.)

Mason & Cox, Ltd., Adelaide, S. Australia. (*Castings.*) (ADELAIDE.)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord), France. (*Ingots and plates.*) (VALENCIENNES.)

Melbourne Iron & Steel Mills Pty., Ltd., Brooklyn, Melbourne, Australia. (*Ingots.*) (MELBOURNE.)

Meridionales, Fonderies, Marseilles, France. (*Castings.*) (MARSEILLES.)

Mesta Machine Co., West Homestead, Pa., U.S.A. (*Ingots, castings and forgings.*) (PITTSBURGH.)

MIAG (Muhlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*) (HANOVER.)

Midvale Company, The, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Miike Machinery Works of the Mitsui Mining Co., Ltd., Omuta-Shi, Japan. (*Castings.*) (SHIMONOSEKI.)

Milanesi Vanzetti, Fonderie Acciaierie, Milan, Italy. (*Castings.*) (GENOA.)

Mitsubishi Heavy Industries Reorganized Ltd.,

Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Mihara Locomotive Works, Mihara, Japan. (*Castings and forgings.*) (KOBE.)

Mitsubishi Nippon Heavy Industries Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*) (YOKOHAMA.)

Mitsubishi Shipbuilding and Engineering Co., Ltd., Hiroshima Works, Hiroshima, Japan. (*Castings.*) (SHIMONOSEKI.)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Japan. (*Ingots, blooms, plates, forgings and castings.*) (SHIMONOSEKI.)

Mitsubishi Zosen K.K. (Mitsubishi Shipbuilding and Engineering Co., Ltd.) Nagasaki Shipyard and Engine Works, Saiwai-Machi, Nagasaki, Japan. (*Castings and small forgings.*) (SHIMONOSEKI.)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Forgings and castings.*) (KOBE.)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small castings.*) (KOBE.)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*) (GOTHENBURG.)

Motomeccanica, Società per Azioni, Milan, Italy. (*Small castings.*) (GENOA.)

Nacional Steel Works, Compañia Siderurgica, Volta Redonda, Est. do Rio de Janeiro, Brazil. (*Plates and sections.*) (RIO DE JANEIRO.)

Nantes La Madeleine, Aciéries de, Nantes, Loire-Inférieure, France. (*Castings.*) (NANTES.)

National Enameling & Stamping Co., Granite City, Ill., U.S.A. (PITTSBURGH.)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*) (CALCUTTA.)

National Malleable and Steel Castings Co., Sharon, Pa., U.S.A. (*Ingots and castings.*) (PITTSBURGH.)

Navalmeccanica S/A, Officine Meccaniche e Fonderie, Naples, Italy. (*Castings.*) (NAPLES.)

Nederlandsche Staalfabrieken (v/h J. M. de Muinck Keizer), Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*) (ROTTERDAM.)

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*) (NEWPORT NEWS.)

Nichia Steel Works, Ltd., Kure Factory, Kure, Japan. (*Ingots.*) (SHIMONOSEKI.)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*) (YOKOHAMA.)

Nippon Casting Co., Ltd., Kawasaki, Japan. (*Ingots and castings.*) (YOKOHAMA.)

Nippon Kokan Kabushiki Kaisha.

Asano Dockyard, Yokohama, Japan. (*Forgings.*) (YOKOHAMA.)

Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*) (YOKOHAMA.)

Toyama Electric Iron and Steel Works, Toyama, Japan. (*Ingots for tubes, bars, forgings and castings.*) (YOKOHAMA.)

*Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Plates.*) (YOKOHAMA.)

Tsurumi Shipyard, Tsurumi, Yokohama, Japan. (*Small castings and forgings.*) (YOKOHAMA.)

Nippon Sharyo Seizo Kaisha, Ltd., Nagoya, Japan. (*Castings.*) (KOBE.)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Nippon Tokushu Steel Tube Co., Ltd., Tokyo, Japan. (*Rolling mills for weldless rolled or drawn tubes.*) (YOKOHAMA.)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*) (YOKOHAMA.)

Nisso Steel Manufacturing Co., Ltd.

Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*) (YOKOHAMA.)

Oshima Plant, Tokyo, Japan. (*Castings and small forgings.*) (YOKOHAMA.)

Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*) (YOKOHAMA.)

Nitto Seiko-Jo Co., Ltd., Chigasaki Plant, Chigasaki City, Japan. (*Ingots, billets and forgings.*) (YOKOHAMA).

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

*Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*) (STOCKHOLM.)

Nueva Montana Quijano, S.A., Forjas de los Corrales de Buelna, Provincia de Santander, Spain. (*Bars.*) (BILBAO.)

Oesterreichisch-Alpine Montangesellschaft, Vienna.

*_Works:_ Donawitz, Styria. (*Plates and sections.*) (SALZBURG.)

Works: Kindberg, Styria. (*Rolling mills for small sections and bars.*) (SALZBURG.)

Okano Valve Manufacturing Co., Ltd., Moji. _Works:_ Yukuhashi, Japan. (*Small castings.*) (SHIMONOSEKI.)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*) (KOBE.)

*d'Ougrée-Marihaye, Société Anonyme, Ougrée, near Liége, Belgium. (ANTWERP.)

Pacific States Steel Corporation, Niles, Cal., U.S.A. (*Ingots, sections and bars.*) (SAN FRANCISCO.)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Pacifico, Compañia de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*) (TALCAHUANO.)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais, France. (*Castings.*) (VALENCIENNES.)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy le Sec, (Seine), France. (*Castings.*) (VALENCIENNES.)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Pennsylvania Forge Corporation, Tacony, Philadelphia, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Phœnix Iron & Steel Co., Phœnixville, Pa., U.S.A. (*Sections and bars.*) (PHILADELPHIA.)

*Phoenix-Rheinrohr A. G., Mulheim-Ruhr, Germany. (*Plates.*) (DUSSELDORF.)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A. *Works:* Monessen, Pa. (*Ingots and billets.*) (PITTSBURGH.)

Pracchi, Fonderie Elettriche, Milan, Italy. (*Small castings.*) (GENOA.)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*) (MARSEILLES.)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections and bars.*) (ANTWERP.)

Pugliesi, Acciaierie e Ferriere, Bari, Italy. (*Castings and weldless rolled or drawn tubes.*) (NAPLES.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*) (STOCKHOLM.)

Raufoss Ammunisjonsfabrikker, Raufoss, Norway. (*Castings.*) (OSLO.)

Republic Steel Corporation, Cleveland, O., U.S.A.

Alabama City, Ala., U.S.A. (MOBILE, ALA.)

Buffalo Plant, Buffalo, N.Y., U.S.A. (CLEVELAND,O.)

Central Alloy District, Massillon Plant, Massillon, O., U.S.A. (CLEVELAND, O.)

Chicago Plant, Chicago, Ill., U.S.A.

Works: 118th Street, Chicago. *Rolling mills:* East Chicago, Ind. (*Angles and bars.*) (CLEVELAND, O.)

Cleveland District, Cleveland, O., U.S.A. (CLEVELAND, O.)

Corrigan McKinney Plant. (*Ingots, blooms and billets.*)

Upson Nut Plant. (*Round and square bars.*)

Youngstown Plant, Youngstown, O., U.S.A. (PITTSBURGH.)

*Ruhrstahl A.G., Henrichshütte, Hattingen-Ruhr, Germany. (*Ingots, plates, forgings and castings.*) (DORTMUND.)

Sambre, Aciéries & Minières de la,

Works: Monceau-sur-Sambre, Belgium. (*Sections, bars, billets and blooms.*) (ANTWERP.)

Works: Moncheret, near Acoz. (*Rolling mills for bars.*) (ANTWERP.)

Works: Nimy, Belgium. (*Rolling mills for bars.*) (ANTWERP.)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de,

Usines de Feignies, Feignies (Nord), France. (*Castings.*) (VALENCIENNES.)

Usines de Saint Brieuc, Cotes-du-Nord, France. (*Small castings.*) (NANTES.)

Sande Giesserei, Sande-Oldenburg, Germany. (*Castings.*) (EMDEN.)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings and tubes.*) (STOCKHOLM.)

"Santa Barbara," Sociedad Industrial Asturiana,Fabricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*) (BILBAO.)

Sasebo Ship Industry Co., Ltd., Sasebo, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juery (Tarn), France. (*Castings.*) (MARSEILLES.)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*) (DURBAN.)

Schmidt & Clemens, Edelstahlwerk, Berghausen b/Engelskirchen, Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*) (DUSSELDORF.)

*Schneider & Co., Le Creusot, France. (ST. ETIENNE.)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.

Works: Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*) (SALZBURG.)

Works: Ternitz, Low Austria. (*Castings and bars.*) (SALZBURG.)

Sesto San Giovanni, Società Anonima Acciaierie Elettriche di, Sesto San Giovanni, Milan, Italy. (*Castings.*) (GENOA.)

Sharon Steel Corporation, Sharon, Pa., U.S.A. *Works:* Farrell. (*Ingots and re-rolling billets.*) (PITTSBURGH.)

Shin-Hokoku Seitetsu Co., Ltd., Toyama Plant, Toyama, Japan. (*Ingots.*) (YOKOHAMA.)

S.I.S.M.A. — Societa Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara), Genoa, Italy. (*Rolled bars and rivets.*) (GENOA.)

SKF. Hofors Bruk, Hofors, Sweden. (*Billets, bars and forgings, and thick walled tubes.*) (STOCKHOLM.)

Smedjebackens Valsverks Aktiebolaget, Smedjebacken, Sweden. (*Sections and castings.*) (STOCKHOLM.)

Société Anonyme des Forges, Usines & Fonderies de Haine St. Pierre, Haine St. Pierre, Belgium. (*Castings.*) (ANTWERP.)

*Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*) (HILBRINGEN-SAAR.)

Société Belge Griffin S.A., Merxem, Antwerp, Belgium. (*Castings.*) (ANTWERP.)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*) (VALENCIENNES.)

Société Métallurgique d'Imphy, Usine de Pamiers, Ariège, France. (*Castings and forgings.*) (MARSEILLES.)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*) (ROUEN.)

Sorel Industries, Ltd., Sorel, P.Q., Canada. (*Ingots and forgings.*) (MONTREAL.)

Sorel Steel Foundries Ltd., Sorel, P.Q., Canada. (*Castings.*) (MONTREAL.)

South African Iron & Steel Industrial Corporation, Ltd.,
"Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*) (DURBAN.)
"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*) (DURBAN.)

Stahl-u. Röhrenwerke Reisholz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*) (DUSSELDORF.)

Stahlwerk Mannheim A.G., Mannheim-Rheinau, Germany. (*Ingots, forgings and castings.*) (AUGSBURG.)

Stahlwerke Südwestfalen, A.G., Werk Geisweid, Geisweid Kreis Siegen, Germany. (*Ingots, forgings, bars and thin plates.*) (DUSSELDORF.)

Standard Steel Works Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*) (PHILADELPHIA.)

Stavanger Electro-Staalverk A.S., Jørpeland, near Stavanger, Norway. (*Castings.*) (BERGEN.)

Steel Company of Australia, Pty. Ltd., Coburg, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Steel Company of Canada, Hamilton, Ontario, Canada.
**Works:* Hamilton. (TORONTO.)
Works: Montreal. (*Bars, angles, plates and billets.*) (MONTREAL.)

Steirische Gusstahlwerke, A.G., Vienna. *Works:* Judenburg, Styria, Austria. (*Forgings and bars.*) (SALZBURG.)

*Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden. *Works:* Domnarfvet. (*Castings, ingots, sections and plates.*) (STOCKHOLM.)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema, Italy. (*Ingots, bars, small sections and rivets.*) (GENOA.)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*) (AUGSBURG.)

Strömmens Verksted, A/S, near Oslo, Norway. (*Castings.*) (OSLO.)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Castings.*) (WINTERTHUR.)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*) (KOBE.)

Sumitomo Metal Industries, Ltd.,
Kokura Iron Works, Kokura, Japan. (*Ingots, billets and bars.*) (SHIMONOSEKI.)
Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*) (KOBE.)
Steel Works, Osaka, Japan. (*Castings and forgings.*) (KOBE.)
Wakayama Steel Works, Wakayama, Japan. (*Small ingots, seamless tubes and electric resistance welded tubes.*) (KOBE.)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Forge and rolling mills, also castings.*) (STOCKHOLM.)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*) (STOCKHOLM.)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*) (KOBE.)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Plates, angles and channels.*) (CALCUTTA.)

Teil, Fonderies & Acieries du, Usine du Frayol, Le Teil (Ardeche), France. (*Small castings.*) (MARSEILLES.)

*Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., U.S.A. *Works:* Ensley, Ala. *Rolling mills, also forgings:* Bessemer and Fairfield, Ala. (MOBILE.)

"Terni" Società per l'Industria e l'Elettricità. *Works:* Terni, Italy. (*Ingots, forgings, castings and plates.*) (NAPLES.)

Thompson's (Castlemaine) Ltd., Williamstown, Victoria, Australia. (*Castings.*) (MELBOURNE.)

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*) (SPLIT.)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*) (KOBE.)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*) (YOKOHAMA.)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Toshiba Steel Manufacturing Co., Ltd., Tokyo, Japan. (*Castings, small forgings and sections.*) (YOKOHAMA.)

Tosi, Franco, Società per Azioni, Legnano, Italy. (*Forgings and castings.*) (GENOA.)

Toto Steel Manufacturing Co., Ltd., Tokyo Plant, Tokyo, Japan. (*Sections.*) (YOKOHAMA.)

Trenton Steel Works, Ltd., Trenton, N.S., Canada. (*Forgings.*) (HALIFAX, N.S.)

Trubia, Fabrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*) (BILBAO.)

Turkiye Demir ve Celik Fabrikalari, Karabuk, Turkey. (*Ingots, plates, rolled sections and bars.*) (ISTANBUL.)

Ube Industries, Ltd., Ube Iron Works, Ube, Japan. (*Castings.*) (SHIMONOSEKI.)

Uddeholms Aktiebolag, Uddeholm, Sweden.
Storforsverken, Storfors.
Works: Storfors. (*Seamless tubes.*) (GOTHENBURG.)
Works: Nykroppa. (*Ingots, forgings and bars.*) (GOTHENBURG.)
Hagfors Jernverk. (*Castings.*) (GOTHENBURG.)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*) (LISBON.)

Union de Consommateurs de Produits Métallurgiques et Industriels, U.C.P.M.I., Forges et Aciéries d'Hagondange, Hagondange, Moselle, France. (*Blooms, billets, bars and sections.*) (VALENCIENNES.)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Union Sidérurgique Lorraine, SIDELOR.

Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*) (VALENCIENNES.)

Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (VALENCIENNES.)

Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (VALENCIENNES.)

Union Sidérurgique du Nord de la France.

USINOR GROUPE A.

*Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*) (VALENCIENNES.)

USINOR GROUPE B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*) (VALENCIENNES.)

Usines de Valenciennes. Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*) (VALENCIENNES.)

Union Steel Corporation of South Africa, Ltd. (Usco). *Works:* Vereeniging, Transvaal, South Africa. (*Ingots, billets, small sections, castings and rivet bars.*) (DURBAN.)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.

Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*) (PITTSBURGH.)

Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*) (PITTSBURGH.)

*Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*) (CLEVELAND, O.)

*Homestead District Works, Pa., including McKees Rock Works. (*Ingots, billets, blooms, slabs, plates, sections and forgings.*) (PITTSBURGH.)

Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*) (PITTSBURGH.)

McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*) (PITTSBURGH.)

Ohio Works, Youngstown. (*Ingots, billets and blooms.*) (PITTSBURGH.)

*South Works, South Chicago, Ill. (*Plates, sections and bars.*) (CLEVELAND, O.)

Uraga Shipbuilding Yard, Uraga Dock Co., Ltd., Yokosuka, Japan. (*Castings and small forgings.*) (YOKOHAMA.)

Vancouver Iron Works, Ltd., (Plant No. 2), Vancouver, B.C., Canada. (*Castings.*) (VANCOUVER, B.C.)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*) (DURBAN.)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*) (COPENHAGEN.)

Vereinigte Oesterreichische Eisen-und-Stahlwerke, A.G. *Works:* Liezen, Styria. (*Ingots for forgings.*) (SALZBURG.)

**Works:* Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*) (SALZBURG.)

Vickers Ruwolt Pty., Ltd., Richmond, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*) (VANCOUVER.)

Villa, Giovanni, Società Anonima, Officine Meccaniche-Fucinati-Stampati, Milan, Italy. (*Forgings.*) (GENOA.)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*) (VALENCIA.)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*) (BILBAO.)

Vulcan Iron & Engineering, Ltd., Winnipeg, Manitoba, Canada. (*Castings.*) (MONTREAL.)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Washino Machine Tool Manufacturing & Trading Co., Ltd., Nagoya, Imamura Plant, Japan. (*Small castings.*) (KOBE.)

Welland Electric Steel Foundry Ltd., Welland, Ontario, Canada. (*Small castings.*) (TORONTO.)

Westfalenhütte Dortmund A.G., Dortmund, Germany. (*Ingots, billets, plates, bars, sections and forgings.*) (DORTMUND.)

Wickwire Spencer Steel Division, The Colorado Fuel & Iron Corporation, Claymont, Delaware, U.S.A. (*Plates.*) (PHILADELPHIA.)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*) (STOCKHOLM.)

Wood, Alan, Steel Company, Conshohocken and Ivy Rock, Pa., U.S.A. (*Blooms, billets and thin plates.*) (PHILADELPHIA.)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*) (ANTWERP.)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots and plates.*) (KOBE.)

*Yawata Iron & Steel Manufacturing Co., Ltd., Yawata, Japan. (*Plates, sections, ingots and forgings.*) (SHIMONOSEKI.)

Zelezarna Jesenice, Jesenice, Yugoslavia. (SPLIT.)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*) (SPLIT.)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND. (ARRANGED ACCORDING TO SURVEYING DISTRICTS)

The Works marked with an asterisk have received the Committee's special approval for steel conforming to the requirements of P403.

Adelaide

Mason & Cox Ltd., Adelaide, S. Australia. (*Castings.*)

Amsterdam

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*)

*Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-Furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*)

Antwerp

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi. (*Castings.*)

Allard, Usines & Aciéries, Société Anonyme, Turnhout. (*Small castings.*)

"ARBED," Aciéries Reunies de Burbach-eich-Dudelange.

Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*)

Division de Dedelange, Greisendahl, Luxembourg. (*Rolling mills for plates up to 8 mm. in thickness.*)

Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*)

Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*)

Baume, Société Anonyme des Forges et Laminoirs de, Haine St. Pierre. (*Ingots, bars and sections.*)

Baume et Marpent, Société Anonyme, Division de Baume, Haine St. Pierre. (*Small castings.*)

Boël, Usines Gustave, Soc. An., La Louvière. (*Ingots, forgings, castings, plates and bars.*)

Boom, Travaux Metalliques de, Société Anonyme, Boom. (*Small castings.*)

*Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi. (*Ingots and plates.*)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*)

Cockerill, Société Anonyme John.

**Works:* Seraing.

**Works:* Grivegnée. (*Ingots and plates.*)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*)

Gilson, Société Anonyme des Usines, La Croyère (Bois d'Haine). (*Ingots, blooms, sections, rivet bars and forgings.*)

Hainaut, Société Anonyme Usines Metallurgiques du, Couillet. (*Ingots, blooms, bars, forgings and castings.*)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre. (*Castings.*)

Antwerp—*continued*

Henricot, Usines Emile, Court St. Etienne. (*Castings.*)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*)

La Brugeoise et Nicaise & Delcuve, Société Anonyme, St. Michel-lez-Bruges. (*Castings.*)

Leonard-Giot, Société Anonyme Usines & Aciéries Marchienne-au-Pont. (*Castings.*)

*d'Ougrée-Marihaye, Société Anonyme, Ougrée, near Liége.

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections and bars.*)

Sambre, Aciéries & Minières de la,

Works: Monceau-sur-Sambre. (*Sections, bars, billets and blooms.*)

Works: Moncheret, near Acoz. (*Rolling mills for bars*).

Works: Nimy. (*Rolling mills for bars.*)

Société Anonyme des Forges, Usines & Fonderies de Haine St. Pierre, Haine St. Pierre. (*Castings.*)

Société Belge Griffin S.A., Merxem, Antwerp. (*Castings.*)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi. (*Castings.*)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*)

Augsburg

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein. (*Castings.*)

Stahlwerk Mannheim A.G., Mannheim-Rheinau. (*Ingots, forgings and castings.*)

Streicher, M., Asperg/Württ, near Stuttgart. (*Castings.*)

Baltimore, Md.

*Bethlehem Steel Co., Sparrows Point, Md., U.S.A. (*Plates.*)

Barcelona

Fundiciones Escora S.A., Pi y Margall, 2-Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*)

La Maquinista Terrestre y Maritima S.A., Barcelona, Spain. (*Castings and forgings.*)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*)

Bergen

Stavanger Electro-Staalverk A.S., Jorpeland, near Stavanger, Norway. (*Castings.*)

Bilbao

Babcock & Wilcox, Sociedad Española de Construcciones.
Head Office : Calle Ercilla 1, Bilbao.
Works : Galindo-San Salvador del Valle. (Vizcaya.) (*Castings, ingots and forgings.*)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*)

Deusto, Sociedad Anonima Talleres de, Deusto, Bilbao, Spain. (*Castings.*)

Duro-Felguera, Sociedad Metalurgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars.*)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*)

Española de Construccion Naval, Sociedad.
Works: Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*)
Works: Sesto, near Bilbao. (*Small castings, ingots and forgings.*)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*)

Llodio, Aceros de, Ltda., Llodio, near Bilbao, Spain. (*Small castings, ingots and forgings.*)

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Castings.*)

Nueva Montana Quijano, S.A., Forjas de los Corrales de Buelra, Provincia de Santander, Spain. (*Bars.*)

"Santa Barbara," Sociedad Industrial Asturiana,Fabricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*)

Trubia, Fabrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*)

Cadiz

Espãnola de Construccion Naval, Sociedad, San Carlos Factory, San Fernando, Cadiz. (*Castings.*)

Calcutta

Burn & Co., Ltd., Howrah, India. (*Small castings.*)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Plates, angles and channels.*)

Cleveland, O.

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*)

Bethlehem Steel Co., Buffalo, N.Y., U.S.A.

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*)

*Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*)

Republic Steel Corporation, Cleveland, O., U.S.A.
Buffalo Plant, Buffalo, N.Y., U.S.A.
Central Alloy District, Massillon Plant, Massillon, O., U.S.A.
Chicago Plant, Chicago, Ill., U.S.A.
Works : 118th Street, Chicago. *Rolling mills :* East Chicago, Ind. (*Angles and bars.*)
Cleveland District, Cleveland, O., U.S.A.
Corrigan McKinney Plant. (*Ingots, blooms and billets.*)
Upson Nut Plant. (*Round and square bars.*)

United States Steel Company, Pittsburgh, Pa., U.S.A.
*Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*)
*South Works, South Chicago, Ill. (*Plates, sections and bars.*)

Copenhagen

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*)

*Danske, (Det), Staalvalsevaerk A/S., Frederiksvaerk, Denmark. (*Plates, sections and bars.*)

Helsingors Skibsvaerft-og Maskinbyggeri A/S., Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*)

Dortmund

Dortmund - Hoerder Hüttenunion A. G., Dortmund, Germany.
*Dortmund-Hoerde Works. (*Ingots, plates, sections, bars, forgings and castings.*)
Dortmund Works. (*Bars, sections and forgings.*)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*)

Hüttenwerk Haspe A.G., Hagen-Haspe (Dortmund.) (*Ingots, plates, bars and sections.*)

*Ruhrstahl A.G., Henrichshütte, Hattingen - Ruhr. (*Ingots, plates, forgings and castings.*)

Westfalenhütte Dortmund A.G., Dortmund. (*Ingots, billets, plates, bars, sections and forgings.*)

Durban

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets, and small sections.*)

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*)

South African Iron & Steel Industrial Corporation, Ltd., "Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to $\frac{3}{8}$ inch thick.*)

"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*)

Union Steel Corporation of South Africa, Ltd., "Usco" Steel Works, Vereeniging, Transvaal, S. Africa. (*Ingots, billets, small sections, castings and rivet bars.*)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*)

Dusseldorf

August Thyssen-Hütte A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections and bars.*)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*)

Bochumer Verein Guss-Stahlwerk A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*)

Eisenwerke Mülheim-Meiderich Aktiengesellschaft, Mülheim-Ruhr, Germany. (*Castings.*)

Gussstahlwerk Gelsenkirchen A.G., Gelsenkirchen, Germany. (*Castings.*)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*)

Hahn'sche Werke A.G., Duisburg-Grossenbaum, Germany. (*Bars.*)

*Hüttenwerk Oberhausen, A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*)

Hüttenwerk Rheinhausen, A.G., Rheinhausen, Germany. (*Bars and sections only.*)

*Mannesmann Hüttenwerke A.G., Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*)

*Phoenix-Rheinrohr A.G., Mülheim-Ruhr, Germany. (*Plates.*)

Schmidt & Clemens, Edelstahlwerk, Bergausen b/Engelskirchen, Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*)

Stahl-u. Röhrenwerke Reisholz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*)

Stahlwerke Südwestfalen, A.G., Werk Geisweid, Geisweid, Kreis Siegen, Germany. (*Ingots, forgings, bars and thin plates.*)

Emden

Sande, Giesserei, Sande-Oldenburg, Germany. (*Castings.*)

Genoa

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*)

Ansaldo-Fossati, Stabilimento Meccanico Metallurgico Genovese, S.p.A., Genoa-Sestri, Italy. (*Forgings.*)

Bolzaneto, Acciaieria de Ferriero di, Genoa. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*)

Breda Fonderia, Forgia, Macchine Industriali, Sesto San Giovanni, Milan, Italy. (*Castings and forgings.*)

Breda Siderurgica Società per Azioni, Sesto San Giovanni, Milan, Italy. (*Ingots and sections.*)

Brescia, Acciaieria e Tubificio di, Società Anonima, Brescia. (*Ingots, sections and bars, castings, weldless or water gas welded tubular materials.*)

Caleotto, Acciaieria e Ferriera del, Società Anonima, Lecco, Italy. (*Ingots, bars, small sections and small forgings.*)

Cantieri del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*)

Cantieri Navali Riuniti. *Head Office:* Genoa. *Works:* Cantiere Navale ed Officine Meccaniche di Ancona. (*Small castings.*)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell'Ossola-Villadossola, Italy. (*Castings.*)

Cobianchi, Metallurgica Vittorio, S.A. *Head Office:* Milan; *Works:* Omegna (Novara). (*Castings.*)

"Cogne", Società Anonima Nazionale. *Head Office:* Turin; *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*)

Cornigliano S.p.A., Genoa. (*Ingots and plates.*)

*Cornigliano, Società Italiana Acciaierie. *Head Office:* Genoa; *Works:* Genoa-Cornigliano. (*Ingots, forgings, castings, plates and sections.*)

Dalmine, Stabilimenti di, Società Anonima, Dalmine (Bergamo.) (*Weldless rolled or drawn tubes, hollow pillars and davits.*)

Fabrica Italiana Tubi, Società Anonima, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*)

Faggian, Acciaieri Elettriche Pio, Soc. per Azioni, La Spezia. (*Small castings.*)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works:* Milan. (*Weldless rolled or drawn tubes.*)

*Concordia Works, Sesto San Giovanni. (*Rolling mills for plates.*)

Unione Works, Sesto San Giovanni. (*Ingots, sections, bars, forgings and castings.*)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin. (*Castings and forgings.*)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin. (*Ingots, plates, sections; also seamless and welded tubes.*)

"Ilva" Alti Forni e Acciaierie d'Italia. *Head Office:* Genoa.

Stabilimento di Genoa-Voltri. (*Rivets.*)

Stabilimento di Lovere. (*Sections, bars, castings and forgings.*)

Genoa—*continued*

Stabilimento di Novi Ligure. (*Sections, bars and plates.*)

Stabilimento di Porto Vecchio di Piombino. (*Ingots, blooms, sections and bars.*)

Liguri, Società Anonima Fonderie Acciaierie, Genoa-Sampierdarena. (*Small castings.*)

Milanesi Vanzetti, Fonderie Acciaierie, Milan. (*Castings.*)

Motomeccanica, Società per Azioni, Milan. (*Small castings.*)

Pracchi, Fonderie Elettriche, Milan. (*Small castings.*)

Sesto San Giovanni, Società Anonima Acciaierie Elettriche di, Sesto San Giovanni, Milan. (*Castings.*)

S.I.S.M.A.—Societa Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara), Genoa, Italy. (*Rolled bars and rivets.*)

Stramezzi, P., & C.. Acciaieria e Ferriera di Crema, Crema, Italy. (*Ingots, bars, small sections and rivets.*)

Tosi, Franco, Società per Azioni, Legnano, Italy. (*Forgings and castings.*)

Villa, Giovanni, Società Anonima Officine Meccaniche-Fucinati-Stampati, Milan. (*Forgings.*)

Gothenburg

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Melting furnaces and forge.*)

Bofors Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*)

*Degerfors Jernverks Aktiebolag, Degerfors, Sweden. (*Ingots, plates, sections and bars.*)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Rolling mill for bars.*)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*)

Uddeholms Aktiebolag, Uddeholm, Sweden.

Storforsverken, Storfors. *Works at* Storfors. (*Seamless tubes.*) *Works at* Nykroppa. (*Ingots, forgings and bars.*) Hagfors Jernverk. (*Castings.*)

Halifax, N.S.

Dominion Iron & Steel, Ltd. ; *a subsidiary of* Dominion Steel & Coal Corporation, Ltd., Sydney, N.S. (*Ingots, billets and sections.*)

Maritime Steel and Foundries, Ltd., New Glasgow, N.S. (*Small castings.*)

Trenton Steel Works, Ltd., Trenton, N.S. (*Forgings.*)

Hanover

Borsig A. G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*)

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*)

Hüttenwerke Ilsede-Peine A.G., Peine, Germany. (*Ingots, billets, sections and bars.*)

Hanover—*continued.*

*Hüttenwerke Salzgitter, A.G., Salzgitter-Drütte, Germany. (*Ingots and plates.*)

Klöckner-Georgsmarienwerke, A.G., Osnabrück, Germany. (*Ingots, bars, forgings and castings.*)

MIAG (Muhlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*)

Hilbringen-Saar

Administration Séquestre des Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen (Saar.) (*Castings, ingots, billets, bars and forgings.*)

"ARBED," Acieries Reunies de Burbach - Eich - Dudelange,

Division de Burbach, Sarrebruck.

Burbach Works. (*Ingots, billets and sections.*)

Hostenbach Works. (*Plates.*)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*)

*Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*)

Istanbul

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*)

Turkiye Demir ve Celik Fabrikalari, Karabuk, Turkey. (*Ingots, plates, rolled sections and bars.*)

Kiel

Bach & Co., Nordische Stahlwerke, Neumunster, Germany. (*Castings.*)

Kobe

Aichi Steel Works Ltd.,

Aichi Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Amagasaki Steel Works, Ltd., Amagasaki, Japan. (*Ingots, plates, sections and bars.*)

Daido Steel Co., Ltd.,

Hoshizaki Works, Nagoya, Japan. (*Ingots.*)

Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*)

*Fuji Iron & Steel Co., Ltd., Hirohata Works, Hirohata, Himeji City, Japan. (*Ingots, billets and plates.*)

Fujinagata Shipbuilding Co., Ltd., Osaka, Japan. (*Castings and forgings.*)

Harima Shipbuilding & Engineering Co., Ltd., Aioi, Japan. (*Castings and forgings.*)

Hitachi Ltd., Yasugi Works, Yasugi, Japan. (*Ingots and bars.*)

Hitachi Shipbuilding & Engineering Co., Ltd., Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*)

Kobe—*continued*

Hitachi Shipbuilding Co., Ltd., Chikko Dockyard, Osaka, Japan. (*Castings and forgings.*)

Iino Sangyo K.K., Maizuru Dockyard, Maizuru, Japan. (*Forgings and castings.*)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Steel Corporation.
*Fukai Plant, Kobe, Japan. (*Plates.*)
Hyogo Plant, Kobe, Japan. (*Castings and forgings.*)

Kobe Steel Works, Ltd., Kobe, Japan. (*Castings and forgings.*)

Kobe Steel Works, Ltd., Takasago Plant, Arai, Japan. (*Ingots, forgings and castings.*)

Kokko Chain & Machinery Manufacturing Co., Ltd., Osaka, Japan. (*Angles, bars and castings.*)

Komatsu Manufacturing Co., Ltd., Komatsu, Japan. (*Castings.*)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*)

Mitsubishi Heavy Industries Reorganized Ltd.,
Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots, forgings and castings.*)
Mihara Locomotive Works, Mihara, Japan. (*Castings and forgings.*)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Forgings and castings.*)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small castings.*)

Nippon Sharyo Seizo Kaisha Ltd., Nagoya, Japan. (*Castings.*)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd.
Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*)
Steel Works, Osaka, Japan. (*Castings and forgings.*)
Wakayama Steel Works, Wakayama, Japan. (*Small ingots, seamless tubes and electric resistance welded tubes.*)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*)

Washino Machine Tool Manufacturing & Trading Co., Ltd., Nagoya, Imamura Plant, Japan. (*Small castings.*)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots and plates.*)

Lisbon

Alves, Alfredo, & Cia. (Filhos), Amadora, Portugal. (*Castings.*)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*)

Los Angeles

Bethlehem Pacific Coast Steel Corporation, Los Angeles 54, Cal., U.S.A. (*Round bars.*)

Columbia-Geneva Steel, (Division United States Steel Co.), Torrance, Cal., U.S.A. (*Round bars and sections.*)

Geneva Steel Company (United States Steel Corp., Subsidiary), Geneva, Utah, U.S.A. (*Plates.*)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*)

Malmö

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*)

Marseilles

d'Alais, Compagnie des Mines Fonderies et Forges, Tamaris (Gard), France. (*Castings.*)

Meridionales, Fonderies, Marseilles, France. (*Castings.*)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juery (Tarn), France. (*Castings.*)

Société Métallurgique d'Imphy, Usine de Pamiers, Ariège, France. (*Castings and forgings.*)

Teil, Fonderies & Acieries du, Usine du Frayol, Le Teil (Ardeche), France. (*Small castings.*)

Melbourne

Melbourne Iron and Steel Mills, Pty., Ltd., Brooklyn, Melbourne. (*Ingots.*)

Steel Company of Australia, Pty., Ltd., Coburg, Melbourne. (*Castings.*)

Thompson's (Castlemaine) Ltd., Williamstown, Victoria. (*Castings.*)

Vickers, Ruwolt, Pty., Ltd., Richmond, Melbourne. (*Castings.*)

Mobile, Ala.

Kilby Steel Co., Furnace Division, Anniston, Ala., U.S.A. (*Ingots.*)

Republic Steel Corporation, Alabama City, Ala., U.S.A.

*Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., U.S.A. *Works:* Ensley, Ala.; *Rolling mills and forgings:* Bessemer and Fairfield, Ala.

Montreal

Canadian Car and Foundry, Steel Foundry Division, Longue Pointe, Montreal, P.Q., Canada. (*Castings.*)

Canadian Tube and Steel Products, Ltd., 5765, Hamilton Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*)

Lynn Macleod Metallurgy, Ltd., Thetford Mines, P.Q., Canada. (*Castings.*)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*)

Sorel Industries, Ltd., Sorel, P.Q., Canada. (*Ingots and forgings.*)

Sorel Steel Foundries, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. *Works:* Montreal. (*Bars and angles, plates and billets.*)

Vulcan Iron & Engineering, Ltd., Winnipeg, Manitoba, Canada. (*Castings.*)

Nantes

Etablissements J. J. Carnaud et Forges de Basse-Indre, Basse-Indre, Loire-Inférieure, France. (*Castings.*)

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*)

Nantes La Madeleine, Aciéries de, Nantes, Loire-Inférieure, France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines & Aciéries de, Usines de Saint Brieuc, Cotes-du-Nord. (*Small castings.*)

Naples

"Ilva" Alti Forni e Acciaierie d'Italia. *Head Office:* Genoa.

Stabilimento di Bagnoli. (*Ingots, sections and bars.*)

Stabilimento di Torre Annunziata, Centrale. (*Ingots, sections and bars.*)

Navalmeccanica S/A, Officine Meccaniche e Fonderie, Naples, Italy. (*Castings.*)

Pugliesi, Acciaierie e Ferriere, Bari. (*Castings and weldless rolled or drawn tubes.*)

"Terni" Società per l'Industria e l'Elettricha. *Works:* Terni. (*Ingots, forgings, castings and plates.*)

Newcastle, N.S.W.

*Broken Hill Proprietary Co., Ltd., Iron and Steel Works, Newcastle, N.S.W. (*Plates, bars, sections and castings.*)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*)

Newport News, Va.

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*)

Oslo

Christiania Spigerverk, Oslo. (*Ingots and bars, also rivet bars.*)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen. (*Small castings.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Castings.*)

Strömmens Verksted, A/S, near Oslo. (*Castings.*)

Philadelphia, Pa.

Alan Wood Steel Company, Conshohocken and Ivy Rock, Pa., U.S.A. (*Blooms, billets and thin plates.*)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Bethlehem Steel Co., Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*)

Lebanon, Pa., U.S.A. (*Rolling mills for bars.*)

Steelton, Pa., U.S.A. (*Forgings and castings.*)

Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., U.S.A. (*Castings.*)

*Central Iron & Steel Co., Harrisburg, Pa., U.S.A. (*Rolling mills.*)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Castings.*)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*)

Fairmount Steel Corporation, Philadelphia, Pa., U.S.A. (*Ingots and forgings.*)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Castings.*)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*)

*Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*)

Midvale Company, The, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small castings.*)

Pennsylvania Forge Corporation, Tacony, Philadelphia, Pa., U.S.A. (*Forgings.*)

Phœnix Iron & Steel Company, Phœnixville, Pa., U.S.A. (*Sections and bars.*)

Standard Steel Works Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*)

Wickwire Spencer Steel Division, The Colorado Fuel & Iron Corporation, Claymont, Delaware, U.S.A. (*Plates.*)

Pittsburgh, Pa.

American Locomotive Co., Railway Steel Spring Division, Latrobe, Pa., U.S.A. (*Ingots.*)

Bethlehem Steel Co., Johnstown Plant, Johnstown, Pa., U.S.A.

Crucible Steel Company of America, Pittsburgh Crucible Division, Midland, Pa., U.S.A.

Pittsburgh, Pa.—*continued*

Empire Steel Corporation, Mansfield, O., U.S.A. (*Ingots.*)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A.

Mesta Machine Co., West Homestead, Pa., U.S.A. (*Ingots, castings and forgings.*)

National Enameling & Stamping Co., Granite City, Ill., U.S.A.

National Malleable & Steel Castings Co., Sharon, Pa., U.S.A. (*Ingots and castings.*)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A. *Works:* Monessen, Pa. (*Ingots and billets.*)

Republic Steel Corporation, Cleveland, O., U.S.A., Youngstown Plant, Youngstown, O., U.S.A.

Sharon Steel Corporation, Sharon, Pa., U.S.A. *Works :* Farrell. (*Ingots and re-rolling billets.*)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.

Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*)

Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*)

*Homestead District Works, Pa., (*including* McKees Rock Works.) (*Ingots, billets, blooms, slabs, plates, sections and forgings.*)

Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*)

McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*)

Ohio Works, Youngstown. (*Ingots, billets and blooms.*)

Rio de Janeiro

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*)

Nacional Steel Works, Companhia Siderurgica, Volta Redonda, Est. do Rio de Janeiro, Brazil. (*Plates and sections.*)

Rotterdam

Bakker N. V., Machinefabriek-Staalgieterij, Ridderkerk. (*Ingots and castings.*)

Nederlandsche Staalfabrieken (v/h J. M. Muinck Keizer), Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*)

Rouen

Société Anonyme des Hauts Fourneaux, Forges et Aciéries de Pompey, Usines du Manoir à Pitres (Eure.) (*Castings.*)

Société Métallurgique de Normandie, Mondeville. (*Ingots, blooms, billets and bars.*)

St. Etienne

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dome. (*Ingots, rolled bars and forgings.*)

Chatillon-Commentry et Neuves Maisons Compagnie, Usines Saint Jacques de Montlucon Commentry, Montlucon, France. (*Castings, ingots, forgings, sheets and sections.*)

Commentry - Fourchambault et Decazeville, Société Anonyme de, Imphy (Nievre). (*Ingots, forgings, bars and sections.*)

Compagnie des Ateliers et Forges de la Loire,
*Usines de St. Etienne, St. Etienne (Loire).
Usines d'Unieux, Unieux, (Loire). (*Forgings.*)

Guérigny, Forges Nationales de la Chaussade à, Nièvre, France. (*Ingots, bars and forgings.*)

Marine et d'Homecourt, Compagnie des Forges et Aciéries de la, St. Chamond (Loire.)

Marrel Frères, Société Anonyme des Etablissements, Usines des Etaings, near Rive-de-Gier, (Loire).

*Schneider & Co., Le Creusot.

Salzburg

Böhler, Gebr., & Co., Aktiengesellschaft, Vienna, Austria.
Works: Kapfenberg, Styria. (*Ingots, castings, forgings and bars.*)

Oesterreichisch - Alpine Montangesellschaft, Vienna.
**Works :* Donawitz, Styria. (*Plates and sections.*)
Works : Kindberg, Styria. (*Rolling mills for small sections and bars.*)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.
Works: Ternitz, Low Austria. (*Castings and bars.*)
Works: Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*)

Steirische Gusstahlwerke, A.G., Vienna.
Works: Judenburg, Styria. (*Forgings and bars.*)

Vereinigte Oesterreichische Eisen-und-Stahlwerke A.G.,
Works: Liezen, Styria, Austria. (*Ingots for forgings.*)
**Works:* Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*)

San Francisco, Cal.

Bethlehem Pacific Coast Steel Corporation, South San Francisco, Cal., U.S.A. (*Ingots, small sections and bars.*)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*)

Pacific States Steel Corporation, Niles, Cal., U.S.A. (*Ingots, sections and bars.*)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*)

Seattle, Wash.

Bethlehem Pacific Coast Steel Corporation, Seattle, Wash., U.S.A. (*Sections and bars.*)

Isaacson Iron Works, P.O. Box 3028, Seattle, Wash., U.S.A. (*Ingots.*)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*)

Shimonoseki

Amagasaki Iron & Steel Manufacturing Co., Ltd., Kure Works, Kure, Japan. (*Ingots and castings.*)

Hitachi Ltd., Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*)

Japan Steel Works Ltd., Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*)

Miike Machinery Works of the Mitsui Mining Co., Ltd., Omuta-Shi, Japan. (*Castings.*)

Mitsubishi Shipbuilding & Engineering Co., Ltd., Hiroshima Works, Hiroshima, Japan. (*Castings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Japan. (*Ingots, blooms, plates, forgings and castings.*)

Mitsubishi Zosen K.K. (Mitsubishi Shipbuilding & Engineering Co., Ltd.) Nagasaki Shipyard & Engine Works, Saiwai-Machi, Nagasaki, Japan. (*Castings and small forgings.*)

Nichia Steel Works, Ltd., Kure Factory, Kure, Japan. (*Ingots.*)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*)

Sasebo Ship Industry Co., Ltd., Sasebo, Japan. (*Castings and forgings.*)

Sumitomo Metal Industries, Ltd., Kokura Iron Works, Kokura, Japan. (*Ingots, billets and bars.*)

Ube Industries, Ltd., Ube Iron Works, Ube, Japan. (*Castings.*)

*Yawata Iron and Steel Manufacturing Co., Ltd., Yawata, Japan. (*Plates, sections, ingots and forgings.*)

Split

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*)

Zelezarna Jesenice, Jesenice, Yugoslavia.

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*)

Stockholm

*Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*)

Stockholm—*continued*

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Bruks-koncernen).

Works: Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*)

Works: Forsbacka. (*Blooms, billets, tubes and forged and rolled bars.*)

Works: Horndal. (*Bars and angles.*)

Works: Osterbybruk. (*Castings, forgings and rolling mill for bars.*)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Castings and bars.*)

Kanthal, A/B, Hallstahammar, Sweden. (*Castings and bars.*)

Kohlswa Jernverks Aktiebolag. (*Melting furnaces, foundry forge and rolling mills for bars and small sections at* Kolsva, Sweden.)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*)

*Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*)

SKF. Hofors Bruk, Hofors, Sweden. (*Billets, bars, forgings and thick walled tubes.*)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings, and tubes.*)

Smedjebackens Valsverks Aktiebolaget, Smedjebacken, Sweden. (*Sections and castings.*)

*Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden. *Works:* Domnarfvet. (*Castings, ingots, sections and plates.*)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Forge and rolling mills, also castings.*)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*)

Sydney, N.S.W.

Australian Electric Steel Ltd., Alexandria, Sydney, N.S.W. (*Small castings.*)

*Australian Iron & Steel, Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*)

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W. (*Castings.*)

Talcahuano

Pacifico, Compania de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*)

Toronto, Ontario

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars and angles.*)

Atlas Steels Ltd., Welland, Ontario, Canada. (*Ingots and bars.*)

Canada Foundries & Forgings, Ltd., Welland, Ontario, Canada. (*Forgings.*)

Dominion Foundries & Steel, Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*)

*Steel Company of Canada, Hamilton, Ontario, Canada. (*Bars and angles, plates and billets.*)

Welland Electric Steel Foundry, Ltd., Welland, Ontario, Canada. (*Small castings.*)

Trieste

Bertoli fu Rudolfo, Società Anonima Officine Fratelli, Udine. (*Castings, forgings, bars and sections.*)

Bolzano, Società per Azioni Acciaierie di, Bolzano, Italy. (*Castings, ingots, billets, bars and forgings.*)

Gorizia, Società Anonima Fonderie Officine di, Gorizia. (*Small castings.*)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza. (*Castings, bars, sections and forgings.*)

"Ilva" Alti Forni e Acciaierie d'Italia. *Head Office:* Genoa, Italy.

Stabilimento di Marghera. (*Castings; also rolling mills for small sections and bars.*)

*Stabilimento di Servola. (*Ingots and plates.*)

Valencia

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*)

Valenciennes

Baume et Marpent, Société Anonyme, Division de Marpent, Marpent, Nord, France. (*Castings.*)

Blanc-Misseron, Société Francaise des Acieries de, Quievrechain, Nord, France. (*Ingots and castings.*)

Chiers, Société des Hauts-Fourneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, bars and sections.*)

Constructions Electriques de Jeumont, Forges et Ateliers de, Jeumont (Nord.) (*Castings.*)

Constructions Mecaniques, Société Francaise de, (Anciens Etablissements Cail), Denain, Nord, France. (*Castings, ingots, forgings, blooms, bars and sheets.*)

de Wendel et Cie, S/A, Hayange, Moselle, France.

*Usine de Fenderie. (*Plates.*)

Usine de St. Jacques. (*Sections.*)

l'Est, Société des Aciers Fins de, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*)

Firminy, Société Anonyme des Aciéries des Forges de, Usine des Dunes Leffrinckoucke, Boîte Postale No. 41, Malo-les-Bains, France. (*Ingots, billets, blooms, bars and forgings.*)

Fives-Lille, Compagnie de, Société Anonyme, Fives-Lille (Nord). (*Ingots, castings and forgings.*)

Valenciennes—*continued*

Gennevilliers, Aciéries de, Gennevilliers, Seine, France. (*Castings.*)

Grosse Forge, Aciéries et Ateliers de, Maurice Dembiermont & Cie., Hautmont (Nord). (*Forgings.*)

Haine-St.-Pierre et Lesquin, Société Anonyme de Aciéries de, Lesquin-lez-Lille (Nord). (*Castings.*)

Hauts-Fourneaux, Société Anonyme des, Forges et Aciéres de Pompey, Division Dieulouard. (*Ingots, blooms, billets and bars.*)

Hauts-Fourneaux, Société Anonyme des, Forges et Aciéries de Pompey, Usines de Pompey, Mthe. & Melle. (*Ingots, plates, angles and round bars.*)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*)

*Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies, de la Providence, Hautmont (Nord). (*Ingots, plates and sections.*)

Lorraine-Escaut S.A.,

Département Tubes, Usine d'Anzin, Anzin (Nord). (*Ingots and weldless rolled or drawn tubes.*)

*Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle). (*Sections and plates.*)

Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle.) (*Ingots, blooms, bars and sections.*)

Usine de Sedan, Sedan (Ardennes). (*Plates.*)

Usine de Thionville, Thionville (Moselle). (*Forgings.*)

Louvroil-Montbard-Aulnoye, Société Anonyme, Aulnoye (Nord). (*Weldless rolled or drawn tubes.*)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais. (*Castings.*)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord). (*Ingots and plates.*)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais. (*Castings.*)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy le Sec (Seine), France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de, Usines de Feignies, Feignies (Nord). (*Castings.*)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*)

Union de Consommateurs de Produits Metallurgiques et Industriels, U.C.P.M.I., Forges et Aciéries d'Hagondange, Hagondange, Moselle, France. (*Blooms, billets, bars and sections.*)

Union Siderurgique Lorraine, SIDELOR, Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*)

Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

Valenciennes—*continued.*

Union Siderurgique du Nord de la France.

USINOR GROUPE A.

*Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*)

USINOR GROUPE B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*)

Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*)

Vancouver, B.C.

A.1. Iron & Steel Foundry Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Canadian Sumner Iron Works Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Vancouver Iron Works, Ltd., (Plant No. 2) Vancouver, B.C., Canada. (*Castings.*)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*)

Whyalla

Broken Hill Proprietary Co., Ltd., Steel Foundry, Whyalla, S. Australia. (*Castings.*)

Winterthur

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*)

Fischer, Société Anonyme des Aciéries ci-devant Georges, Schaffhouse, Switzerland. (*Castings.*)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Castings.*)

Yokohama

Azuma Steel Works Ltd.,

Azuma Plant, Tokyo, Japan. (*Ingots for plate.*)

Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*)

Fuji Iron & Steel Co., Ltd.,

Works at Kamaishi, Japan. (*Sections and bars.*)

Works at Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*)

Works at Muroran, Japan. (*Billets, sections and bars.*)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small castings and forgings.*)

Hitachi Ltd.,

Hitachi Works, Hitachi, Japan. (*Castings.*)

Mito Works, Mito-Shi, Japan. (*Ingots, forgings and castings.*)

Ishikawajima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Forgings.*)

Yokohama—*continued*

*Japan Steel Works Ltd., Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*)

Kanto Special Steel Works Ltd., Yokohama, Japan. (*Forgings.*)

Kanto Steel Manufacturing Co., Ltd., Shibukawa Plant, Toyoaki-Maru, Gunma Prefecture, Japan. (*Ingots and rivet bars.*)

Kawasaki Steel Corporation, Chiba Iron & Steel Mill, Chiba, Japan. (*Slabs for plates.*)

Mitsubishi Nippon Heavy Industries, Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*)

Nippon Casting Co., Ltd., Kawasaki, Japan. (*Ingots and castings.*)

Nippon Kokan Kabushiki Kaisha,

Asano Dockyard, Yokohama, Japan. (*Forgings.*)

Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*)

Toyama Electric Iron & Steel Works, Toyama, Japan. (*Ingots for tubes and bars, forgings and castings.*)

*Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Plates.*)

Tsurumi Shipyard, Tsurumi, Yokohama, Japan. (*Small castings and forgings.*)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*)

Nippon Tokushu Steel Tube Co., Ltd., Tokyo, Japan. (*Rolling mills for weldless rolled or drawn tubes.*)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*)

Nisso Steel Manufacturing Co., Ltd.,

Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*)

Oshima Plant, Tokyo, Japan. (*Castings and small forgings.*)

Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*)

Nitto Seiko-Jo Co., Ltd., Chigasaki Plant, Chigasaki City, Japan. (*Ingots, billets and forgings.*)

Shin-Hokoku Seitetsu Co., Ltd., Toyama Plant, Toyama, Japan. (*Ingots.*)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*)

Toshiba Steel Manufacturing Co., Ltd., Tokyo, Japan. (*Castings, small forgings and sections.*)

Toto Steel Manufacturing Co., Ltd., Tokyo Plant, Tokyo, Japan. (*Sections.*)

Uraga Shipbuilding Yard, Uraga Dock Co., Ltd., Yokosuka, Japan. (*Castings and small forgings.*)

MANUFACTURERS OF ALUMINIUM ALLOYS

The following establishments have complied with the conditions contained in P 20 to P 23 of the Rules and are recognised by the Committee for the manufacture of aluminium alloys for shipbuilding purposes.

United Kingdom

Almin Ltd.
- International Alloys Ltd., Aylesbury, Bucks. (*Aluminium alloys.*)
- Southern Forge Ltd., Langley, Bucks. (*Aluminium alloy products.*)

Birmetals Ltd., Quinton, Birmingham. (*Aluminium alloys and products.*)

James Booth & Co., Ltd., Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Falkirk. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Milton, Staffs. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Warrington. (*Aluminium alloys and products.*)

High Duty Alloys Ltd., Winscales, Workington. (*Aluminium alloys and products.*)

Imperial Chemical Industries, Ltd., Waunarlwydd, near Swansea. (*Aluminium alloys and products.*)

E. & E. Kaye, Ltd., Enfield, Middlesex. (*Aluminium alloys and products.*)

Northern Aluminium Co., Ltd., Banbury. (*Aluminium alloys and products.*)

Northern Aluminium Co., Ltd., Newport, Mon. (*Aluminium alloys and products.*)

T. I. Aluminium Ltd., Tyseley, Birmingham.
- South Wales Aluminium Works. (*Aluminium alloys and products.*)
- Tyseley Works. (*Aluminium alloy products.*)
- Redditch Works (*Aluminium alloy products.*)

Austria

Osterreichische Metallwerke A.G., Ranshofen bei Braunau am Inn. (*Aluminium alloy products.*)

Vereinigte Aluminium-Werke A. G., Braunau am Inn. (*Aluminium alloys.*)

Belgium

S.A. Sidal, Société de L'Aluminium, Duffel. (*Aluminium alloys and products.*)

Canada

Aluminum Company of Canada, Ltd. (No. 1 Plant), Shawinigan Falls, Quebec. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Etobicoke Works, Long Branch, Ont. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Kingston, Ont. (*Aluminium alloys and products.*)

Germany

Aluminiumwalzwerke Singen G.m.b.H., Singen (Hohentwiel). (*Aluminium alloys and products.*)

Osnabrücker Kupfer - und Drahtwerk, Osnabrück. (*Aluminium alloys and products.*)

Vereinigte Deutsche Metallwerke A.G., Frankfurt-Heddernheim. (*Aluminium alloys and products.*)

Vereinigte Deutsche Metallwerke A.G., Werdohl-Eveking. (*Aluminium alloys and products.*)

Vereinigte Leichtmetallwerke G.m.b.H., Bonn. (*Aluminium alloys and products.*)

Vereinigte Leichtmetallwerke G.m.b.H., Hanover. (*Aluminium alloys and products.*)

Westfälische Leichtmetallwerke, Nachrodt. (*Aluminium alloys and products.*)

Holland

N. V. Nederlandsche Aluminium Maats., Utrecht. (*Aluminium alloys and products.*)

Italy

Lavorazione Leghe Leggere, Marghera, (Venice). (*Aluminium alloys and products.*)

Trafilerie e Laminatoio di Metalli S.p.A., Milan. (*Aluminium alloys and products.*)

Norway

A/S Nordisk Aluminiumindustri, Oslo.
- Hoyanger Works. (*Aluminium alloys.*)
- Holmestrand Works. (*Aluminium alloy products.*)

Spain

Eduardo K. L. Earle, Lejona. (*Aluminium alloys and products.*)

Sweden

A/B Svenska Metallverken, Finspong. (*Aluminium alloys and products.*)

Switzerland

Aluminium S.A., Menziken. (*Aluminium alloys and products.*)

Société Anonyme pour l'Industrie de l'Aluminium, Chippis. (*Aluminium alloys and products.*)

MANUFACTURERS OF STEEL WIRE ROPE

The following establishments have complied with the conditions contained in P 18 of the Rules and are recognised by the Committee for the manufacture of steel wire towlines, mooring ropes, and standing rigging.

United Kingdom

Binks Bros., Ltd., London.
Bridgwater Wire Rope Works Ltd., Bridgwater.
British Ropes Ltd., Cardiff.
British Ropes Ltd., Doncaster.
British Ropes Ltd., Gateshead-on-Tyne.
British Ropes Ltd., Glasgow.
British Ropes Ltd., London.
British Ropes Ltd., Retford.
Bruntons (Musselburgh) Ltd., Musselburgh.
Catherall Ropeworks Ltd., near Sunderland.
Wm. Cooke & Co., Ltd., Sheffield.
Joseph Crawhall & Sons Ltd., Gateshead-on-Tyne.
Dawson & Usher Ltd., Sunderland.
Dixon Corbitt Ltd., Gateshead-on-Tyne.
Edge & Sons Ltd., Shifnal.
Geo. Elliott & Co., Ltd., Cardiff.
Frew Bros. Ltd., Coatbridge.
Garnock Bibby & Co., Ltd., Liverpool.
Glaholm & Robson Ltd., Sunderland.
Glover Bros. (Mossley) Ltd., near Manchester.
Hall's Barton Ropery Co., Ltd., Hull.
R. Hood Haggie & Son, Ltd., Newcastle-on-Tyne.
John I. Hopper Ltd., Thornaby-on-Tees.
Latch & Batchelor Ltd., Birmingham.
Martin, Black & Co. (Wire Ropes), Ltd., Coatbridge.
Overton Bros. Wire Ropes Ltd., Hull.
D. Morgan Rees & Sons Ltd., Cardiff.
Rylands Bros., Ltd., Warrington.
Scottish Wire Rope Co., Ltd., near Glasgow.
John Shaw Ltd., Worksop.
Sheffield Wire Rope Co., Ltd., Sheffield.
Terrells Wire Ropes Ltd., Bristol.
Archd. Thomson, Black & Co., Ltd., Port Glasgow.
Tyne Wire Rope Manufacturing Co., Ltd., South Shields.
Webster & Co., Ltd., Sunderland.
Whitecross Co., Ltd., Warrington.
Wrights' Ropes Ltd., Birmingham.

Australia

Australian Wire Rope Works Pty. Ltd.,Newcastle,N.S.W.

Belgium

Cableries & Corderies du Hainaut, S.A., Dour, near Mons.
Cableries et Fonderies de & à Montignies s/Sambre.
Corderies & Cableries Belges, et Gilly, S.A., near Charleroi.
Corderies d'Ans & Cableries de Renory, S.A., Renory.
Corderies J. B. Ligny, S.A. des Gilly.
Gonzalez Cock S.A., Lokeren.
Laurent Frères, Boussu-lez-Mons.
Le Lis, S.A., Hamme-sur-Durme.
Marcel Vermeire, Cablerie, Hamme.
Vertongen-Goens S.A., Termonde.

Canada

Canada Wire & Cable Co. Ltd., Smith Falls, Ontario.

Denmark

Jacob Holm & Sønners Fabriker, A/B., Copenhagen.
Randers Rebslaaeri A/S., Randers.

France

Laminoirs-Trefileries-Cableries de Lens, Lens.
Trefileries et Laminoirs du Havre.

Germany

Berkenhoff & Drebes A.G., Asslarer Hutte.
J. Bertram K.G. Drahtseilwerk, Soest.
Braucke, Adolf vom. A.G., Ihmerterbach.
Dortmunder Drahtseilwerke G.m.b.H., Dortmund.
Drahseilerei Gustav Kocks, Mülheim (Ruhr)—Broich.
Drahtseilwerke G.m.b.H., Bremerhaven.
Drahtseilwerke Hugo Wohlfahrt, Neheim/Ruhr.
Felten & Guilleaume, Koln-Mulheim.
Gempt, J. H., Lengerich/Westf.
Hamburger Drahtseilerei G.m.b.H., Hamburg.
Hüttenwerk Oberhausen A.G. Werk Gelsenkirchen vorm. Boecker & Comp.
Klockner-Drahtindustrie G.m.b.H., Dusseldorf.
J. & W. Vornbaumen K.G., Iburg.
Westdeutsche Seilindustrie Paul Stoessel, Osterrath b/Dusseldorf.
Westfalische Drahtindustrie, Hamm.
Westfalische Union A.G., Lippstadt.
Westfalische Union A.G. fur Eisen und Drahtindustrie, Drahtseilwerk Oesede.
Wolf, Gustav, Gutersloh.

Holland

Staaldraadkabel & Herculestouwfabriek J.C. den Haan, Gorinchem.

Vereenigde Touwfabrieken, Leiderdorp.

India

National Rolling & Steel Ropes Ltd., Calcutta.

Italy

Acciaierie Ferriere Lombarde Falck, Sesto San Giovanni.

Giuseppe Fratello Redaelli, Brescia.

"Ilva" Alti Forni e Acciaierie d'Italia, Torre Annunziata.

Industrie Metallurgiche Piemoentesi, Susa.

Stabilimenti G. Fornara & Co., Turin.

Trafilerie E Corderie Italiane, Sesto San Giovanni.

Trafilerie E Corderie Venete, Padova.

Japan

Asahi Wire Rope Manufacturing Co. Ltd., Osaka.

Kawasaki Steel Corporation, Chiba Iron and Steel Mill, Chiba City.

Kokoku Iron & Steel Wire Mfg. Co. Ltd., Osaka.

Kokoku Iron & Steel Wire Mfg. Co. Ltd., Tokyo.

Nippon Steel Wire & Wire Rope Co. Ltd., Osaka.

Nishida Wire Rope Mfg. Co. Ltd., Osaka.

Sensyu Seiko Co. Ltd., Kaizuka.

Shinko Kosen Kosaku Co., Ltd., Amagasaki.

Showa Wire Rope Mfg. Co. Ltd., Osaka.

Japan—*continued*

Tatsumi Rope Mfg. Co. Ltd., Osaka.

Teikoku Sangyo Kabushiki Kaisha, Osaka.

Tokyo Seiko Kaisha, Kokura.

Tokyo Seiko Kaisha, Tokyo.

Toyo Wire Rope Manufacturing Co. Ltd., Osaka.

Norway

Mandal Stal A/S, Mandal.

Norsk Staaltaugfabrik, Trondheim.

Tonsberg Reperbane A/S., Tonsberg.

Spain

"Nueva Montana Quijano", S.A., Santander.

Trenzas y Cables de Acero S.A., Barcelona.

Sweden

Blombacka A/B., Lindfors.

Fagersta Bruks A/B., Fagersta.

Garphytte Bruks A/B., Garphyttan.

Gunnebo Bruks A/B., Varberg.

Hellefors Bruks A/B., Hellefors.

Lesjofors A/B., Lesjofors.

Spangholms Bruks A/B., Sya.

Stallinefabriken, David Ahlquist A/B, Roslags-Nasby.

United States of America

Jones & Laughlin Steel Corporation, Muncy, Pa.

Le Tourneau Westinghouse Co., Peoria, Illinois.

PROVING ESTABLISHMENTS

The following proving establishments are recognised by the Committee of Lloyd's Register for the testing of anchors and chains while licensed by the Ministry of Transport for that purpose.

Principal Superintendent : Mr. H. Murphy. (*Stationed at Netherton.*)

	Superintendents
Netherton (near Dudley)—Lloyd's Proving House	Mr. H. Murphy
Low Walker-on-Tyne—Lloyd's Proving House	Mr. R. J. Vogan
Chester (Saltney)—Lloyd's Proving House	Mr. S. Bolton
Glasgow—Lloyd's Proving House	Mr. L. L. Wright
Cardiff—Lloyd's Proving House	Mr. F. W. Dovey
Cradley Heath—Lloyd's Proving House	Mr. H. Phillips

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The following machines have been recognised by the Committee for the testing of anchors and chain cables intended for ships other than those registered in the U.K.

Australia

Falkiner Machinery Co., Proprietary, Ltd., South Brisbane, Queensland (for testing chains up to 100 tons).

Austria

Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl, Carinthia.

Belgium

Adh. Demanet, Gosselies, Belgium (for testing chains up to 260 tons).

Beliard, Crighton & Co., Ltd., Antwerp (for the testing of anchors and chain cables up to 100 tons).

Ed. Demaret & Fils, Heppignies, Nr. Fleurus.

Mercantile Marine Engineering & Graving Dock Co., Antwerp.

Société Anonyme des Anciens Etablissements Wattelar-Francq, Jumet.

Canada

Canada Chain & Forge Co., Ltd., Granville Island, Vancouver, B.C.

Dominion Chain Co., Ltd., Niagara Falls, Ontario.

McKinnon-Columbus Chain, Ltd., St. Catherine's, Ontario.

France

Carlier et Cie., St. Amand-les-Eaux (Nord).

Davaine, Fils et Cie., St. Amand-les-Eaux (Nord) (for the testing of chain cables up to 132 tons).

Etablissement Sirot-Mestreit, St. Amand-les-Eaux (Nord).

Fonderies Meridionales, Marseilles (for the testing of anchors only).

Forges Nationales de la Chaussade à Guérigny, Nièvre (for testing chain cables up to 300 tons).

Paoli, J., & Co., Marseilles.

Société Anonyme des Chaineries de St. Amand-les-Eaux, Etablissements Dorémieux Fils & Cie., St. Amand-les-Eaux (Nord).

Société des Forges des Fresnes, Fresnes-sur-Escaut (Nord) (for the testing of chain cables up to 150 tons.)

Veille, A., & Co., Le Havre.

Germany

Dortmund-Hoerder Hüttenunion A.G., Dortmund Works, Dortmund (for the testing of anchors only).

Dortmunder Kettenfabrik Bernhard Mester, Wetterstr. 10, Dortmund.

Duisburger Kettenfabrik H. d'Hone, Duisburg (for testing chain cables up to 250 tons).

Fröndenberger Kettenfabrik, Heinrich Prünte, Frondenberg-Ruhr (for testing chain cables up to 120 tons).

Gutehoffnungs-Hütte A.G., Oberhausen-Sterkrade.

Germany—*continued*

Hansa Kettenfabrik Haunschild & Co., Dortmund.

Howaldtswerke A.G., Hamburg.

Joto-Werk Josef Topp, Kettenfabrik, Warmen (Ruhr).

Kettenfabrik Kalthof, August Thiele; and August Thiele G.m.b.H., Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.

Kettenwerke Schlieper, Grune, Westphalia.

Kettenwerke Schlieper, Sichtigvor, Westphalia.

Mannheimer Ankerfabrik u. Hammerwerk Gdbr. Heuss, Mannheim-Industriehafen (Ruhr).

Stuelcken, H. C., Sohn, Schiffswerft und Maschinenfabrik, Hamburg.

Theile, J. D., Schwerte-Ruhr.

Holland

Koninklijke Nederlandsche Grofsmederij, Leiden.

N.V. Anker-& Kettingfabriek "Schiedam" (*Managing Director :* P. Th. Verhoeff), Schiedam.

Italy

Acciaieria e Ferriera del Caleotto S.p.A., Lecco.

Acciaierie Weissenfels, Catenificio Fusine di Valromana, Udine (for the testing of small chains only).

Navalmeccanica S.A., Officine Meccaniche & Fonderie, Naples (for the testing of anchors only up to 60 tons).

Japan

Hamanaka Chain Manufacturing Co., Ltd., Himeji.

Japan Mechanical Chain Manufacturing Co., Ltd., Osaka.

Kobe Steel Works, Ltd., Kobe (for the testing of anchors only).

Kokko Chain & Steel Manufacturing Co., Ltd., Osaka.

Komatsu Manufacturing Co., Ltd., Komatsu.

Koyo Chain Manufacturing Co., Ltd., Osaka.

Tokyo Chain Works Co., Ltd., Tokyo.

Tokyo Steel Casting Co., Ltd., Tokyo.

Norway

Norsk Kjettingindustri A/S, Mandal.

Spain

Cadenas y Forjádos, S.A., J. M. Olavarri, Bilbao. *Works :* Durango, Vizcaya.

Forjas de San Martin de Pedro Framis, Barcelona (for testing chains up to 16 tons).

Hijos di Vicinay, S. en C., Ochandiano, Vizcaya.

Sweden

Gunnebo Bruks Aktiebolag, Gunnebobuck, Västervik (for testing chains up to 20 tons).

Jarnbirger A/B, Orsa.

Ljusne Woxna Aktiebolag, Ljusne.

Ramnäs Bruks Aktiebolag, Ramnäs.

Statens Provningsanstalt (Government Establishment), Stockholm.

United Kingdom

Taylor, Samuel, & Sons (Brierley Hill) Ltd., Brierley Hill, Staffs.

United States

American Chain Co., Braddock, near Pittsburgh, Pa. ; and York, Pa. (for testing chains up to 22 tons).

Baldt Anchor, Chain and Forge Division of the Boston Metals Co., Chester, Pa.

Bellingham Chain & Forge Co., South Bellingham, Wash.

Buckeye Steel Castings Co., Columbus, O. (for breaking tests on chain cables only).

Carroll Chain Co., Columbus, O.

Continental Chain Corporation, Fieldsboro, N.J.

General Steel Castings Corporation, Eddystone, Pa. (for the testing of anchors only).

Johnson-Farmer Chain Co., Lebanon, Pa.

McKay Company, McKees Rocks, near Pittsburgh, Pa.

National Erie Co., Erie, Pa. (for the testing of anchors only).

National Malleable and Steel Castings Co., Sharon, Pa.

Portland Chain Manufacturing Co., Portland, Or.

Republic Steel Corporation, Round Chain Division,
Broadway & Chaincraft Roads, Cleveland, O.
6921, East Marginal Way, Seattle 8, Wash.
196, Freeway, So. San Francisco, Cal.

Taylor, S. G., Chain Company, Hammond, Indiana.

Yugoslavia

Poduzece "Uljanik," Pula, Yugoslavia.

N.B.—Ships supplied with anchors and chain cables tested at any of the establishments in the foregoing lists will have the notation of LACP in the Appendix to the Register Book, provided that in the case of machines other than at licensed Proving Houses in the U.K., the tests are carried out under the supervision of a Surveyor to the Society.

By order of the Committee,

W. J. FERGUSON,

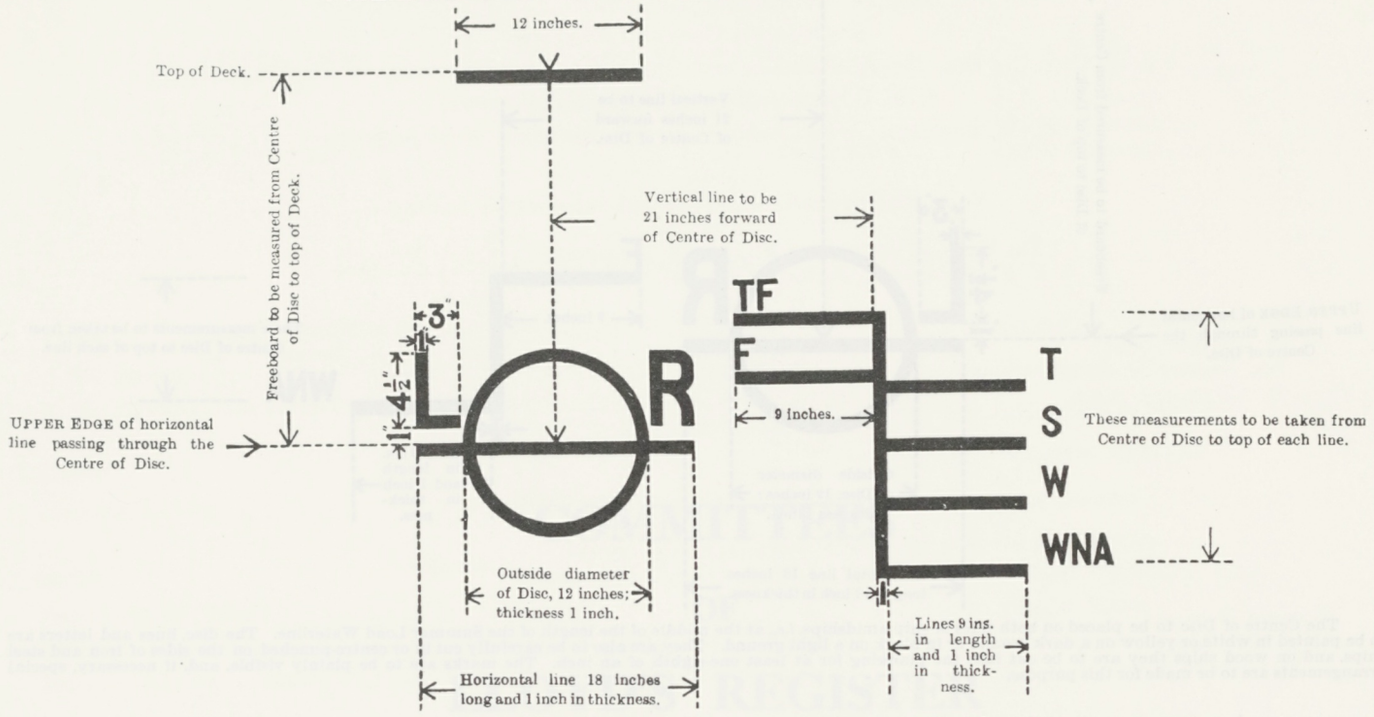
Secretary and Chief Executive.

LONDON.—*September, 1955.*

ASSIGNMENT OF FREEBOARD

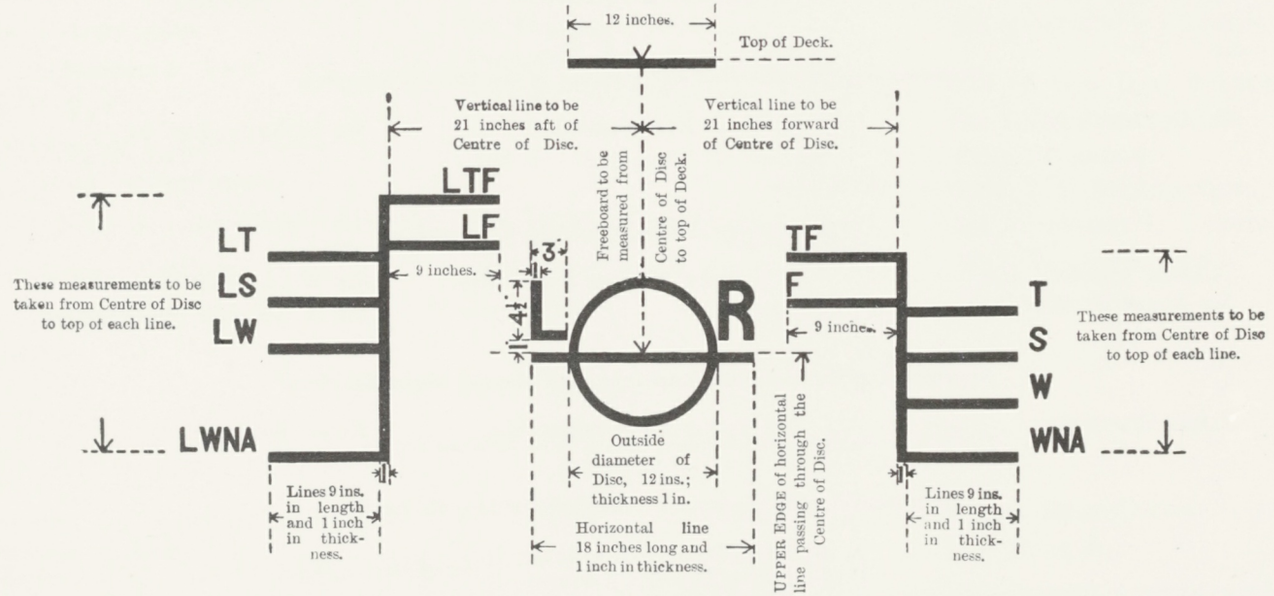
The Committee of Lloyd's Register are empowered to assign freeboards to British ships and to ships registered in other countries. Forms of application for the assignment of freeboard can be obtained from the London Office, or other offices of the Society.

FREEBOARD MARKING FOR STEAMERS



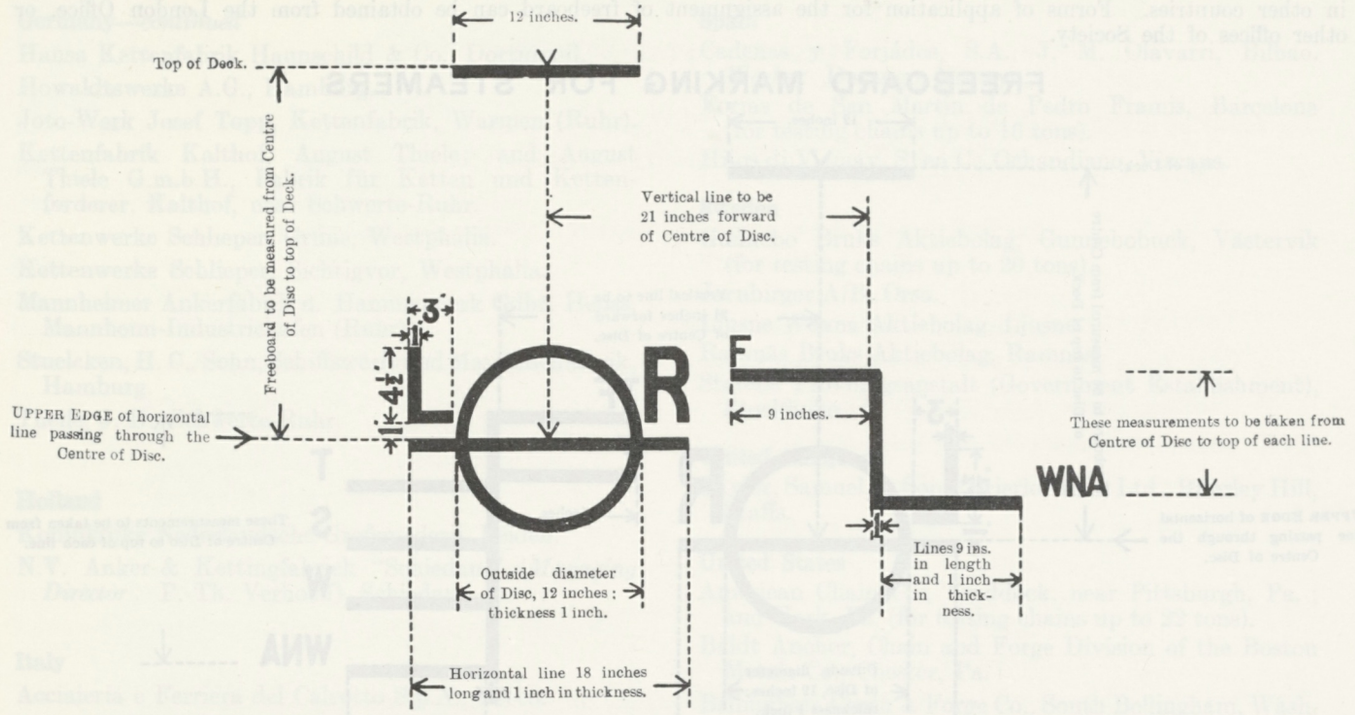
The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

FREEBOARD MARKING FOR STEAMERS CARRYING TIMBER DECK CARGOES



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for the purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

FREEBOARD MARKING FOR SAILING SHIPS



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose.

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Ship and Engineer Surveyor ... M. Caldwell

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Telephone: 28097.
Telegrams: Surveyor, Santos.
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Telephone No. Bishop 7506.
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Ship and Engineer Surveyor ... R. W. Stonehouse

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Office: Ground Floor, A. Marin Building, 36, Chareh Sultan Hussein
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Telegrams: Lloydsreg, Suez.

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Office: Djalan Raja Darmo No. 130, Sourabaya, Indonesia.
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Telegrams: Surveyor, Sourabaya.

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Telegrams: c/o Wilson, Madras.

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VIZAGAPATAM

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Telegrams: Surveyor, Vizagapatam.

Ship Surveyor ... ... A. J. Smith

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BASRA

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PENANG

Office: Surveyor of Ships Office, Government Building, Beach Street, (P.O. Box 437), Penang, Federation of Malaya.
Telegrams: Surveyor of Ships, Penang.

Ship and Engineer Surveyor ... *J. Duncan

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SINGAPORE

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Ship and Engineer Surveyor ... F. K. L. Birk

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Telegrams: Lloydsreg, Wellington.

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Office: Farmers' Co-op. Auct. Co., Ld., 14-18, Customs Street East. Auckland. G.P.O. Box 2682.
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Telegrams: Lloydsreg, Auckland.

Ship and Engineer Surveyor ... G. M. Kersey
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Telegrams: Cellular, Dunedin.

Ship and Engineer Surveyor ... B. A. White

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Telegrams: Oileng, Lyttelton.

Ship and Engineer Surveyor ... *E. P. Combellack

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Telephone No. 3531.
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